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The purpose of this contract is to develop and demonstrate modern technologies and management practices that optimize the performance of the Department of Defense's Clothing and Textile's supply chain. Specific objectives are (1) eliminate recruit training center clothing stockouts; (2) minimize operational and inventory investment costs across the entire supply chain; and (3) level production requirements placed on manufacturers. Clemson Apparel Research participates in the C&T supply chain as a model quick-response shirt manufacturer supporting Army and Marine Corps RTC.

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Clemson Apparel Research

Demonstration Contract

Years 6 and 7
Final Technical Report

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Clemson Apparel Research
Demonstration Contract
Years 6 and 7 Final Technical Report

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CAR YEAR 7 DEMONSTRATION CONTRACT
VIRTUAL PRIME VENDOR & MANUFACTURING TASKS
September 22, 2003

1. Executive Summary

Background. The purpose of Clemson Apparel Research's Demonstration Contract was to develop and demonstrate leading edge technologies and management practices that optimize the performance of the Department of Defense's Clothing and Textile (C&T) supply chain (SC). Specific objectives were to (1) eliminate recruit training center (RTC) clothing stockouts, (2) minimize operational and inventory investment costs across the entire supply chain, and (3) level production requirements placed on manufacturers. Clemson Apparel Research (CAR) participated in the C&T supply chain as a model quick-response (QR) shirt manufacturer supporting high priority needs of all Services.

This paper presents a summary of the work and most important lessons learned for contract Years 1-7 and detailed results of all tasks in Years 6-7. Earlier reports covered years 1-3 and 4-5 in detail.

Demonstration approach. In Years 6 and 7 CAR refined the understanding of SC science, further developed the BalancedFlow solution for SC optimization, demonstrated the benefits of Paired Production Line manufacturing, and further improved special measurement manufacturing. CAR continued to operate the model demonstration factory by making both military and commercial shirts. At the end of this contract CAR successfully transitioned to operating the factory without ARN funding.

Key Lessons Learned. Huge opportunities exist for SC improvements between military customers and especially across entire military clothing and textile SCs. Advanced standard practices and information systems make improvements, but radical changes are required to achieve radical improvements. Radical improvements include eliminating all stockouts at the end of the SCs while reducing inventories by at least 50 percent and reducing manufacturing costs by 5 to 30 percent.

When the fundamentals of supply chain science are not understood, solutions to improve supply chain performance are ineffective – and the understanding of supply chain science is extremely limited. There was no comprehensive source for this knowledge so we collected the components from many different sources, integrated and perfected them through our SC demonstrations, and created a seminar to teach the basics.

Just thinking of the supply chain as extending from fiber to warfighter opens far greater opportunities than the classical thinking that a supply chain consists only of ones customers and suppliers. We learned that there are no integrated models or information systems that address SC-wide optimization Therefore, our research efforts turned to the creation of the first such system that includes concepts and software collectively named BalancedFlow.

BalancedFlow optimizes SC performance based on SC science and proven radical, but common sense management concepts rather than standard business practices and software. We learned that meaningful collaboration between SC partners is virtually non-existent, but mandatory for supply chain optimization. We crated BalancedFlow to eliminate all reasons for not collaborating, but getting companies to work together is still extremely difficult.

Throughput speed must be the driving force and primary metric for SC optimization. The two core problems that must be eliminated to achieve optimization are known as Murphy and the bullwhip effect. Murphy is the variation in customer wait times once a replenishment order is submitted and the bullwhip effect is the alternating feast and famine of inventory flowing down all supply chains. The bullwhip effect is caused primarily by standard economic order quantity or reorder point systems that batch demand rather than flow it upstream. All SCs operate in a state of co-variance in which the variation in customer wait times drives the variation in customer demand and the variation in customer demand drives the variation in customer wait times.

The ARN's BalancedFlow solution consists of 15 integrated solutions that break the co-variance cycle by minimizing Murphy and the bullwhip effect.

Military SCs are different from commercial SCs because of the uniqueness of military end-items and components and because of the differences in inventory strategies. Commercial items are normally produced early to forecasts, but military unique items are much more contract driven because of the high risks of making these items to forecast. Military items are unique because they are designed to meet higher functional requirements. Therefore, stockouts are more critical for military items and components than for commercial items. Large inventories of military items are necessary to meet wartime surge and long-procurement lead-times plus interest expenses are not part of the cost of military ownership. Thus minimizing military inventories is not a driving business imperative as it is for commercial inventories. This all results in slightly different objectives for military and commercial SC optimization:

Both SCs have the objective of maximum consumer satisfaction at minimum total cost.

Commercial supply chain objectives are maximum customer satisfaction at minimum total manufacturing, inventory, and distribution costs.

Military supply chain objectives are maximum warfighter satisfaction in peacetime and wartime at minimum total manufacturing, distribution, and replenishment costs while maintaining minimum funds invested in inventory.

The implication of these differences is that military inventories downstream of end-item manufacturing will be significantly larger than they would be for optimum commercial SC performance. BalancedFlow should be used to attain inventory balance in days of supply to minimize warfighter stockouts. Unlike commercial supply chains there is no driving business mandate to minimize inventories so excesses should be re-distributed for maximum wartime surge flexibility and total minimum peacetime costs. In fact, a combination of the new procurement system and the application of BalancedFlow across the entire SC will minimize manufacturing costs by eliminating emergency orders and the bullwhip effect. Contracts must be

awarded at the PGC level and size assortments must be made as late as possible to fully minimize manufacturing costs. Locking item sizes in early is a major flaw of the current system.

Dual production lines must be established to eliminate the final few long stock out items, build trust in the system, and eliminate all co-variances. Paired Production Lines as demonstrated by CAR is an option for establishing dual lines and reducing overall costs.

The key to achieving radical improvements consistent with the ARN's goal is the full implementation of the balanced flow concept across the entire supply chains. Anything less will not result in radical improvements.

2. Purpose, Background, and Key Lessons Learned

2.1 Purpose

The purpose of CAR's Demonstration contract was to support the ARN's goal of creating customer driven uniform manufacturing (CDUM). Specific CDUM objectives were to:

Eliminate stockouts of C & T items at Army and Marine Corps recruit training centers (RTCs).

Minimize operational and inventory investment costs across the military components and end-item manufacturers of the Army and Marine Corps recruit clothing SC.

Reduce retail and wholesale inventories by 50 percent.

Level manufacturing requirements.

2.2 Background

Reference is made to the two earlier Clemson Apparel Research Contract Demonstration Reports for Years 1-3 and 4-5 which document all detailed research and lessons learned from the beginning of the demonstration contract until the beginning of this reporting period. Only the most important lessons learned are brought forward and included with those of Years 6 and 7 in Section 2.3 of this report.

CAR supported the ARN through supply chain research, manufacturing demonstrations, and SC demonstrations with RTCs and other manufacturers. CAR conducts independent research, maintains active membership in research committees of trade associations, and conducts research with other ARN partners. CAR demonstrates the results of this research plus other cutting-edge technologies and management practices by operating a fully functional model factory that produces commercial and military shirts.

CAR's research in the first two years contributed greatly to the evolution of the ARN's efforts in ordering and inventory management. The ARN began its approach with a balanced effort with focus groups in development and design, pre-production and production, and ordering and distribution. In Year 2, the ARN realized that the greatest opportunities for meeting the ARN objectives were in strategic inventory management rather than manufacturing or design. The overall ARN focus shifted to logistics through the formation of a virtual prime vendor (VPV) effort structured to make the most of these opportunities. Working closely with the Program Manager, DSCP, and other ARN partners, the CAR demonstration identified these opportunities, provided the essential concepts, and helped define the generic steps required to implement VPV.

During years 4 and 5 the ARN efforts shifted to installing software at RTCs to support the transfer of inventory ownership from the Army and Marine Corps to DSCP. CAR's efforts shifted to refinement of the supply chain principles and the complete development of what was known originally as the Balanced Inventory Flow Replenishment System or BIFRS.

In years 6 and 7 CAR expanded BIFRS into a unique comprehensive SC-wide execution system with concepts and software collectively named BalancedFlow™. BalancedFlow can be used to schedule all types of manufacturing supply chains beginning with single production lines and extending across entire supply chains. It drives the generation of replenishment orders, electronic vendor managed inventory, and production scheduling locally or across entire SCs. The term BIFRS has been retained for the application of the BalancedFlow concept to military clothing supply chain execution. In Years 6 and 7, BIFRS software development was limited to the generation of new delivery orders as a tool for DSCP Item Managers. The entire BalancedFlow concept and algorithms are documented in detail in separate proprietary documents. Key concepts, lessons learned, and operations are presented in this document as they apply to military BIFRS.

CAR's initial CDUM research and demonstration efforts resulted in three major thrust areas within the CAR demonstration which were carried through Year 7:

Manufacturing. The demonstration began with the focus on the manufacturing line and that continued to be one of our three major areas of emphasis, but it became last in overall priority during Years 4 and 5. The original purpose of the manufacturing demonstration was to locate, integrate, demonstrate, and transfer to commercial manufacturers the most modern manufacturing technologies and management practices. The primary benefit of the manufacturing demonstration turned out to be all the lessons learned by CAR as a true manufacturer with all the problems and challenges faced by DSCP's contractors. These lessons have enabled CAR to keep the ARN research focused on the objectives that ultimately resulted in significant benefit to the overall program. The end-item manufacturing line was thought to be the most scarce and expensive resource within the entire SC. However, we learned in Year 6 that SC constraints are often further up the SC than end-item contractors and must be addressed in order to significantly improve the performance at the downstream end of the SC.

For a military apparel supply chain, many non-manufacturing bottlenecks are larger than manufacturing, but the DSCP contracting changes and the ARN research solutions have eliminated or developed the means of eliminating most of these for recruit clothing. Everything possible external to the manufacturing line must be done to minimize manufacturing delays and costs. Everything possible within manufacturing must be done to minimize total manufacturing costs. This is a very different approach to manufacturing than first envisioned by the ARN partners and a primary reason why manufacturing cost reduction was not retained as the primary focus of the ARN.

Special Measurement Supply Chain. Shortly after the demonstration began, DSCP requested CAR manufacture special measurement (SM) shirts because of their large backorders and their inability to interest commercial manufacturers. These SM shirts became the primary focus of our production line for most of the first year and the ensuing pre-production work evolved into several very successful independent research efforts to complete the total CDUM vision. We were forced to build efficient automated modules to manage orders, manipulate patterns, and ship garments within required time frames. Our research revealed unacceptable

error rates as well as unacceptable delivery times with the old SM ordering system. The Web-based electronic order form (EOF) was created to overcome these ordering problems through a separate, but closely associated contract that is fully documented in a report entitled "Clemson Demo Electronic Order Form Final Report." The first three years of the pattern manipulation work is documented in detail in a separate report entitled "Clemson Demo Special Measurement Final Report." We continued to improve the electronic order form and the automated pattern software through Year 7. During Year 7, a separate Task was undertaken at CAR to modernize the EOF software and add non-recruit items to the form.

Early in Year 3 CAR implemented ARN-AIMS, the ARN's primary automated production software developed at Georgia Tech. CAR has continued to use and modify ARN-AIMS through Year 7 to minimize our pre-and post-production times and costs. It serves CAR very well, but it is clear that it must be rewritten completely to be viable for commercial application for military or commercial production facilities.

In Year 4 CAR created automated cut-file generation for the original SM shirts that CAR manufactured. Unfortunately, we integrated this capability with ARN-AIMS and did not build it as a stand-alone module. In Year 5 DSCP awarded CAR a separate contract to manufacture all 24 military dress shirts. CAR added all shirts to the ARN-AIMS system and now makes about 5,000 SM shirts per year well within the delivery requirements of one week for RTC requirements and two weeks for all other requirements. At the beginning of Year 6, CAR began a new ARN Task of extracting the SM software from ARN-AIMS and adding additional SM items to the automated marker making system. Early in Year 6 the decision was made to split this out as a separately funded DSCP Task. At the end of Year 7 DSCP decided it was not appropriate for CAR to complete this project, but to offer the project to open competition.

Supply Chain Execution. The highest priority thrust area became the SC replenishment execution concept named BalancedFlow with the supporting constraints-based scheduling software. This became the highest priority area once the ARN realized that opportunities for improvement above the manufacturing floor greatly exceed the opportunities on the manufacturing floor. In addition, solutions developed for moving product down the supply chain also apply to the manufacturing floor as well as to all classes of items. BalancedFlow is a supply chain-wide management concept with supporting BIFRS software and that re-balances the flow of orders up the supply chain and product back down the chain on a frequent basis. Currently there are no other systems that address SC-wide optimization. At the end of Year 7 it was used in a limited application only demonstrate the generation of new delivery orders for DSCP C&T Item Managers.

2.3 Key Lessons Learned Years 1-7

Key lessons learned are presented in two parts. Section 2.3.1 consists of lessons learned that apply to all SCs and manufacturing in general plus an operational overview of BalancedFlow. Section 2.3.2 consists of the application of the lessons learned specifically to military C & T SCs.

2.3.1 General Lessons Learned

Supply Chain Scope. The term "supply chain" has two general meanings. The meaning with the widest scope includes the movement of product and all associated transactions from the first raw material producers through a defined group of interdependent manufacturing and movement processes to the ultimate consumers. However, virtually everyone working in supply chains limit the scope of "supply chain" to their relationships and transactions with their immediate suppliers and/or customers. Many limit the scope just to their suppliers. The reason for this limited scope is easy to understand. Virtually no one conducts transactions further than one tier up or down their SC and, even if someone desires to go further, there are no practices or information systems to support them. Thus, ordering, forecasting, vendor managed inventories and all associated SC activities and decision-making processes are sequential – one SC section at a time.

Partners in SCs vary greatly in their ability to pass critical information upstream in a timely manner. Some have practices supported by modern systems that move information fairly quickly, but most have virtually no such capabilities. This is a one key reason that SCs are so lengthy (commercial clothing and textile SCs are 14 to 16 months long and military SCs are even longer) and contain so much excess inventory. CAR's research has broken out of this limited thinking and developed concepts and tools for automatically scheduling the synchronized re-balancing and movement of product down entire SCs according to the operating rules established by the SC partners.

Supply Chain Collaboration. Radical improvements cannot be realized with traditional practices and business systems because traditional practices and business systems are major barriers to radical improvement. Radical improvements within companies are well documented through the use of radical approaches such as Six Sigma, Theory of Constraints, and Lean Manufacturing. Yet, only a very few companies have implemented these approaches internally. It is virtually impossible to find two or more companies within a single SC willing to implement radical approaches together. CAR's BalancedFlow system provides simple, common sense, and "radical" concepts and software, but collaboration is still required before SC performance can be optimized.

Companies do not collaborate for their mutual benefit for many reasons. This is uncharted territory and there are no models to follow; the companies do not understand the level of benefits available through collaboration; they believe they must keep "arms length" relationships to drive supplier prices down; they believe better standard software systems are the answer; and they believe they would lose competitive advantages by working together. CAR's solutions dispel all of these reasons for not collaborating, Still, contracts with "pass down" SC partnership requirements will probably be required to establish the minimum level of collaboration necessary for radical improvements.

Supply Chain Science. Supply chain science is the body of knowledge that provides a comprehensive statistical-based understanding of the interdependent processes, operations, and business relationships that exist within and across all supply chains. Once we are able to understand critical process variations and express SC relationships mathematically, we can

accurately control the actions taken through the individual SC sections to achieve our established goal and objectives for entire SCs. CAR's BalancedFlow supply chain execution system is grounded in SC science, fully engages the minds and creative energy of everyone that manages the sections of the SC, and optimizes performance through the synergy of the entire SC in contrast to common local optimization and sequential decision-making.

Total Asset Visibility. Acquiring complete, accurate, and near-real time inventory accuracy is the first technical requirement on the journey to SC optimization. The ARN has been practicing this for some time for the military sections of the military SCs. However, the capturing of accurate intransit inventories has proven problematic because inventories are not believed to be accurate within SAMMS. Item managers track intransit inventories of critically short items very closely by posting data from DD 250s to "shadow" balance sheets. Hopefully the intransit inventory problem will be resolved with BSM. Otherwise Item Managers will have to continue their manual tracking systems.

The BalancedFlow Operational Concept. The BalancedFlow (BF) operational concept is explained in full detail in a separate proprietary document. A brief summary is provided here.

First, the SC partners define the scope of their SC. This consists of the most upstream to the final downstream process plus the specific items contained in the SC. The SC is next divided into SC sections based on a few strategic buffers such as retail, distribution, finished good, and component stocks. Strategic buffers are those that must be retained to protect the SC's constraints. A SC section consists of one strategic buffer at the end of the section and the complete series of upstream processes and non-strategic buffers prior to the next upstream strategic buffers.

Next, the SC partners determine the initial values of 6 operating parameters for each SC section. These parameters include target stockage levels, lead-times, minimum batch quantities, constraints, yields, and surge inventory strategy.

An annual demand forecast is required from all downstream partners and each partner is required to submit inventory status electronically and automatically on a daily basis.

BF runs daily to recommend items, quantities, and priorities for release from each of the strategic buffers. These recommendations are computed using the SC partners' operating parameters in a manner that maintains item balance based on days-of-supply. BF is a customer pull scheduling system rather than standard forecast pushed scheduling systems. Since the output is generated daily for each strategic buffer based on the status of the SC downstream of each strategic buffer, the accuracy of the demand forecast immediately becomes trivial. This contrasts sharply with standard collaboration efforts in which partners constantly strive to improve forecast accuracy.

The SC partners monitor the status of the SC daily using the management charts for each SC section and make small parameter value adjustments as necessary to meet and maintain an optimum balance of the established SC objectives. BF balances the inventories in SC sections in less than each section's lead-time. The BF management charts show the status of each SC section. Inventory problems readily stand out for resolution with sufficient time for corrective

action before stockouts occur at the consumer level. This eliminates emergency expedites and dampens the "feast and famine" manufacturing requirements that are so common.

BalancedFlow Potential Supply Chain Improvements. It is well documented that the proper application of TOC or Lean Manufacturing concepts can reduce inventories, throughput time, and replenishable item stockouts by 50 to 90 percent over standard manufacturing practices within a single company. When integrated TOC and Lean practices are implemented across SCs, the potential levels of improvement are even higher because of the multiplying effect of inventory reductions when organizational boundaries are breached.

Actions To Improve a Supply Chain must be evaluated against all SC Optimization Objectives. Many well-meaning actions are taken at many different places within SCs, but only those that result in a net improvement to the goal of the SC when evaluated against all objectives will have a positive impact on the bottom line. Many improvement actions that make what appears to be large local improvements have no or negative net contributions to SC optimization.

Throughput Speed is the Driving focus and Primary Metric of Supply Chain Optimization. The driving focus and primary metric of SC optimization is throughput speed. All conflicting measurements and rewards must be eliminated. Actions should be taken to minimize throughput times until the net SC-wide benefits are less than the net SC-wide costs in relation to the goal. Removing inventory is the primary method of increasing throughput speed. All non-strategic buffers must be reduced to transfer batches and all strategic buffers must be reduced slowly and carefully until the risk of stockouts at the end of the SC almost becomes unacceptable. Eventually, the limiting constraint to SC optimization becomes the size of transfer batches and transfer batch sizes can only be minimized by a world-class focus on reducing changeover times on bottlenecks.

Supply Chain Performance is Ultimately Limited by Changeover Times on Bottlenecks. Manufacturing capacity is normally the most scarce and costly component of any SC. As batch transfer sizes are reduced to maximize throughput speed, SC capacity is lost on the most constrained bottlenecks – and this could prove most costly. Thus, bottlenecks should always be the focus of world-class changeover time reduction efforts. Research and practice have determined that world-class efforts can reduce changeover times by 50 to 90 percent over traditional practices. As changeover times are reduced, transfer batch sizes can be reduced thereby improving service levels at lower inventory levels. For every day that is removed from manufacturing or transportation processes, a total of two days of time and inventory can be removed from the SC and the SC will still perform at the initial service level.

Core Supply Chain Problems are Demand and Wait Time Variations. It is the variations in customer demand and customer wait times and not the averages that must be reduced to optimize SC performance. All SCs are in a state of perpetual co-variance in which variations in customer demands drive variations in customer wait times and, in turn, wait time variations drive variations in demand. (Customer wait time is basically the same as order ship time or replenishment lead-time.) This state of one variation driving the other must be totally broken and all reasons for each variation must be eliminated for optimum SC performance. Then average times will drop, but most importantly, SC partners will have trust in each other and in their SC

systems and downstream partners will not return to normal irrational ordering behaviors. CAR's research resulted in 15 separate solutions, ending with Paired Production Lines that can be taken to eliminate the co-variance and minimize both variations. All of these solutions except Paired Production Lines are integrated into the BIFRS software.

Traditional Replenishment Processes cause Demand Variations. Common replenishment processes collect the flow of incoming customer demand and pass it upstream less frequently in larger batches because they all operate on reorder point concepts. Large batches of production releases must be reduced to minimum transfer batches and a flow of incoming demand is necessary to ensure productive capacity is employed only on those items that are in shortest supply. Large batches of incoming demand prevents the identification of the items and quantities needed the earliest so constrained capacity is used to make a few urgently needed items and many long supply items.

Flowing Orders Upstream is the Fastest and Greatest SC Improvement with the Smallest Resource Requirement. Customers are in a much stronger position within SCs to make improvements and to demand suppliers make improvements. However, once improvements are made, most of the benefits naturally go to the suppliers. The largest improvement that customers can make is to flow their replenishment orders upstream instead of batching them. However, very few companies understand this and believe the ultimate answer is to demand their suppliers institute vendor managed inventories (VMI). Most suppliers resist doing VMI because the way they normally go about implementing it only pushes inventory costs upstream for a negative impact on their bottom line. An automatic, frequent flow of inventory status and stockage objectives is a much more efficient and less costly way for customers and suppliers to increase sales and reduce inventory costs.

2.3.2 Application of Lessons Learned to Military Clothing Supply Chains

Military and commercial SC optimization goals and objectives are different first because of the unique nature of military items and second because of differences in operational and business objectives.

First, Military Items are different from Commercial Items. Military unique end-items and especially military-unique components make the need to optimize military SCs greater than that of SCs in general. Military items and components are different from commercial items because their functional requirements are higher. This has two SC implications.

Warfighters cannot accept substitutes or go without military unique items as readily as consumers can substitute or go without commercial items. In addition, SCs cannot respond as fast with military unique items as they can with commercial items. Most manufacturers of commercial items all the way up SCs to initial raw material producers launch manufacturing to forecasts well ahead of firm customer orders. This occurs much less frequently for military-unique end-items and components because of the much higher risks should the military orders not materialize. There is a very limited secondary market for military items and they cost more than commercial items. These two differences in military and commercial items themselves are another reason military SCs are much longer than commercial SCs.

Second, Military Operational and Business Objectives are Different than Commercial Objectives. Military SC optimization is different from commercial SC optimization in two strategic aspects. The goal of a commercial SC is to optimize profitability for all SC partners by focusing on customer satisfaction. The goal of a military SC is to optimize warfighter satisfaction at the lowest possible cost. The differences become clearer when we consider the objectives that support each of these goals.

The general objectives that support the optimization of commercial SCs are maximum revenue at minimum total cost. The maximum revenue objective for commercial SCs is the same objective as the warfighter satisfaction objective of military SCs because both objectives can also be measured as the percent of time that consumer demand is met immediately. The two major differences are found in the cost objectives.

In commercial SCs, the cost objectives are to minimize manufacturing, inventory, and distribution costs - all at the same time. Military SCs have the same objectives of minimizing manufacturing and distribution costs, but there are no driving requirements to minimize inventory costs. In fact, inventory investment is intentionally held at a much higher level than necessary from a pure SC operational standpoint because of the needs to meet wartime surge demand and to protect against long-term procurement process delays. In addition, the reduction of interest expenses are a major cost savings when inventories are reduced in commercial SCs, but are of no concern in military SCs because inventory interest expenses are not paid by the military.

***Therefore, the objectives of military SCs are to maximize warfighter service levels in peacetime and wartime while minimizing manufacturing, distribution, replenishment, and inventory costs*.** There is no driving business imperative to minimize inventories and large inventories are required to ensure the primary objective of warfighter support is attained.

The Impact on BalancedFlow. The unique military SC optimization objectives have no significant impact on the BalancedFlow concept or BIFRS. However, it is now clear that inventories must still be balanced in days-of-supply to minimize warfighter stockouts, but total inventory investments must not be reduced to an operational minimum. Instead, when sufficient balance is achieved to protect against stockouts, current excesses should be re-distributed within the SCs to provide flexibility for surge requirements and worst-case procurement process delays.

Early on in this project, everyone believed we needed to decrease significantly manufacturing lead-times and manufacturing batches. This proved to be wrong. The fact that significantly more inventories will be maintained than required for commercial SC optimization actually permits manufacturing lead-times and production batches to be larger than they are now. This will result in significant manufacturing cost reductions. However, inventories need to be re-distributed and BIFRS needs to be employed fully to re-balance and re-distribute inventories and remove all possible administrative lead-times.

In addition, the capability must be created to award contracts at the PGC level and do size assortments at the last possible moment in a routine manner. BIFRS can very efficiently generate

new delivery order requirements that maintain balance, but the procurement system must also have the flexibility to operate in this manner. This is common in commercial practice – firm orders are placed well ahead of time and final colors or sizes are determined at the last possible moment.

Paired Production Lines. The implementation of BIFRS across the entire military SC will optimize inventory balance and create the flexibility for wartime surge. However, there will still be a few long-term stockouts because of various reasons unless redundant production lines are established. The extremely small number of remaining stockouts will, in itself, be trivial. It is the fact that no one can predict ahead of time the items that will fall in this category that causes the problem. Customers who cannot live with stockouts will always insist on stocking more to minimize this problem and this will keep the co-variance cycle alive.

There are a number of ways to address this problem. DSCP ownership of retail assets helps immensely because of the total asset visibility and the ability to keep retail stockage targets low. Some items or groups of items have such large demands that two or more manufacturers are required all the time. Other items do not always have to be in stock. However, redundant manufacturing lines should always be a consideration and Paired Production Lines are always a viable option to solve this final problem.

Paired Production Lines refers to the business strategy of maintaining a pair of production lines making the same items. One line is a very small quick response line for a complete family of items established in a manner to be mutually exclusive from the large, slow-turn, low-cost lines. This is the final solution to completely break the co-variance cycle and attain full customer trust. It is a relatively new business strategy in commercial apparel manufacturing in which the main line produces well ahead of demand to a forecast to enjoy lowest possible manufacturing costs. The small QR line is tied directly to consumer demand so it can make immediately the items that are running out of stock first. Together, these two lines generate the lowest manufacturing costs and highest revenue possible.

Paired production lines will not be required by DSCP provided sufficiently large inventories are maintained downstream of end-item manufacturing and systems are put in place to identify potential critical warfighter shortages in time for adequate reaction in the existing SCs. Otherwise consideration should be given to the implementation of paired production lines for each major family of items.

3. Year 6 Technical Tasks in Detail

3.1 Task 1 - High-Velocity Manufacturing of a Common Shirt

Purpose: Provide a complex supply chain as the integrated test bed for all ARN projects and demonstrate the benefits and costs of high-velocity manufacturing.

Original Task: CAR and CAL POLY will reduce their ARN manufacturing from a total of 300 shirts per week to a total of 150 shirts in order to make more funding available for research. The AG 415 Woman's short sleeve shirt will be manufactured by both Demo sites to support fully a defined, but complex supply chain. This complex supply chain will be used to expand, integrate, and test all individual ARN concepts. This supply chain will be the advanced test bed for all ARN projects beginning with the automated tie-in with QLM Central through the DataMart. CAR will produce 100 shirts per week for 50 weeks per year or a total of 5,000 shirts per full 12 month demo year. CAR and Cal Poly will each receive a separate, normal supply contract from DSCP that will permit complete testing of the entire system including the invoicing and payment processes. DSCP may fund these shirts at the same rate that DSCP is currently paying for its competitive contract for this item. If this occurs, the Demos will be able to accomplish other ARN work for DLA during years 6 and 7.

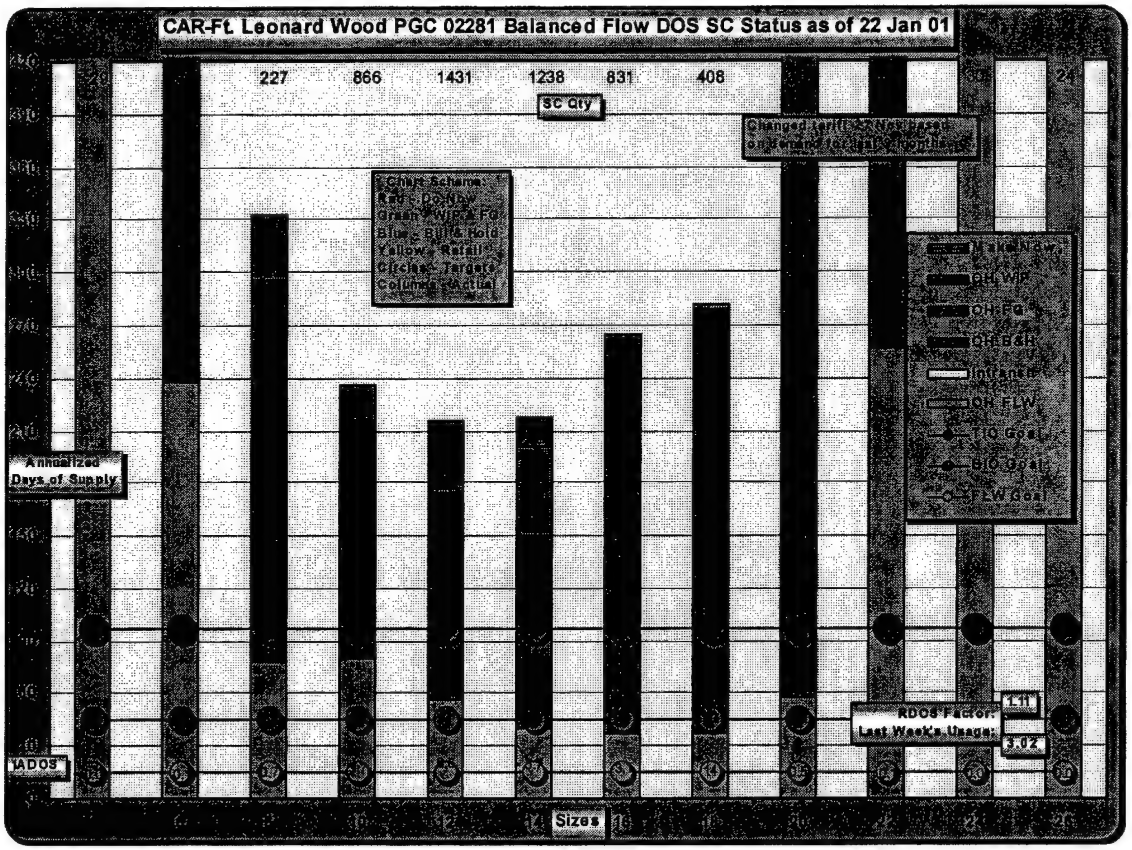
Modified Task: CAR will reduce ARN manufacturing capacity from 150 to 100 shirts per week in order to make more funding available for research. The AG 415 Woman's short sleeve shirt will continue to be the SC test-bed item. Once VIM-BIFRS is operational at Rutter Rex, both manufacturers will be making the same item to support fully a defined, but complex supply chain. This complex supply chain will be used to expand, integrate, and test all individual ARN concepts. This supply chain will be the advanced test bed for all ARN projects beginning with the automated tie-in with QLM Central through the DataMart. CAR will produce 100 shirts per week for 50 weeks per year or a total of 5,000 shirts per full 12-month demo year. DSCP will award CAR a separate, normal supply contract that will permit complete testing of the entire system including the invoicing and payment processes. DSCP may fund these shirts at the same rate that DSCP is currently paying for its competitive contract for this item. When this occurs, CAR will be able to accomplish additional ARN work for DLA during years 6 and 7.

Status and Lessons Learned:

CAR began the year making 100 AG 415 shirts per week for this project using manual BIFRS and inventory data from the SAMMS Data Warehouse to generate the new production requirements each week. The Task was modified in the first month for CAR to partner with Rutter Rex rather than CAL POLY to demonstrate the application of ARN technologies to a pair of production lines – one low cost and one fast-turn. The plan was to activate all AG 515 shirts as well as all Rutter Rex garments as soon as VIM-BIFRS was operational.

The following BIFRS management chart shows the status of the ARN test-bed supply chain as of Jan 01. The SC consisted only of CAR and Ft. Leonard Wood. CAR was running BIFRS

routinely locally and had successfully used it initially to support the Ft. Leonard Wood RTC through the Christmas Exodus with capacity that was a fraction of the total FLW requirement.

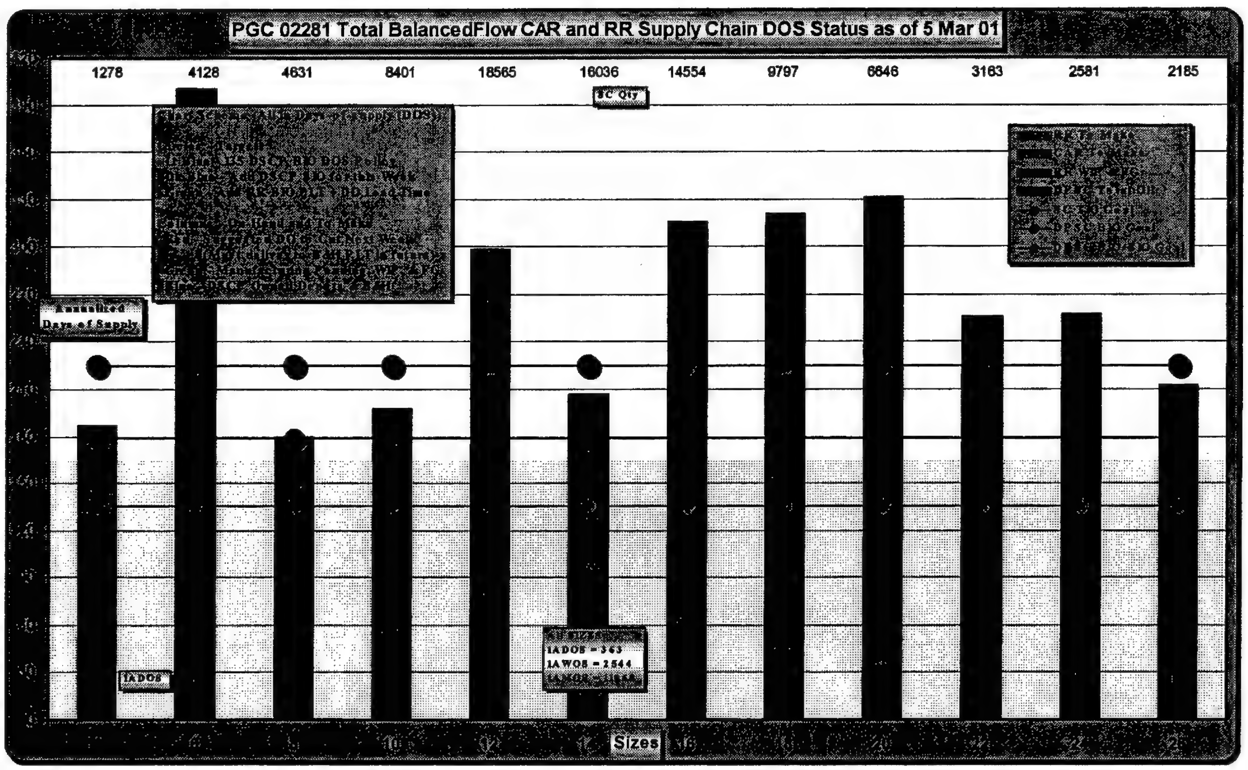


A small capacity buys lots of time when it is used only to make items in shortest supply. This chart clearly shows one of the most profound lessons learned. A small amount of production capacity can buy a lot of time if that capacity is used only to make items and quantities in shortest supply. Each week FLW faxed CAR their inventory status. We used BIFRS to schedule all available capacity and, at the same time, to re-balance the sizes in shortest supply in the SC. This chart shows that this week's capacity was scheduled to make only size 14 shirts. By always filling in the sizes that are in shortest supply, the sizes in longer supply effectively become a second source of supply. The stockage targets are not maintained, but no sizes run out of stock significantly earlier than others. CAR's small capacity was sufficient to delay for well over 300 days the first stock out at FLW. This was more than sufficient time for capacity shortage problems to be resolved. This contrasts sharply with common SC operations in which large production batches are considered optimum – and lots of expedites are then necessary to respond to customer orders – that are not really current needs. This principle became one of the 15 key actions within BalancedFlow – schedule daily the available capacity to make only the items and quantities in shortest supply in the downstream portions of the entire SC.

Total asset visibility is the first requirement for SC optimization. This chart also displays total asset visibility (TAV) for this defined SC. We had learned much earlier that acquiring TAV was the first requirement for SC execution. Over time the display of TAV was standardized in three

basic management charts with the same format as the above chart – one displaying days-of-supply (DOS), one displaying quantity of items, and one displaying dollars invested. The charts showed here display the item sizes in their natural order. We later learned to display the items by descending demand rates with the highest demand size always to the left of the chart and the slowest demand size to the right.

Next, CAR expanded this SC to include RutterRex and all of DSCP's wholesale inventories. The following chart shows the status as of March with all wholesale assets grouped together. This shows the average annual weekly demand to be 2,544 shirts based on the average monthly demand numbers from the SAMMS Data Warehouse.



Existing replenishment methods and systems are major barriers to improved SC performance. By item sizes, the SC was short about 5,000 shirts and excess about 15,000. RutterRex was making about 4,250 per week based on delivery orders and the SC was adding about 1,700 more excess shirts per week. The major problems were the amount of excess inventory and the fact that the RutterRex WIP was almost all in the wrong sizes as shown above! This shirt is not a special situation, but one of the best managed of all the dress shirts and its SC status is typical of all items. The lesson demonstrated here is that this is about the best Item Managers can do with existing tools. There is significant room for improving inventory levels and balance between sizes of items and between different items. No matter how hard managers try, they cannot achieve either balance or low inventories with existing systems and practices.

In March CAR used BIFRS to generate a delivery order plan to drive CAR and RutterRex at a level production rate each month and re-balance the entire SC for the AG 415 SS Woman's Shirt within 90 days. A quick glance at the above chart shows 4 sizes have about 300 DOS and 5 sizes

are close to the target of 180 DOS. It is clear that total production must be reduced drastically from current rates to get to balance and 180 DOS quickly. This would be a great hardship on the contractor and would very likely violate the contract minimum. Therefore, attaining balance becomes the primary goal and attaining the 180 DOS target level must be done over an extended amount of time.

VIM-BIFRS became operational, but contained sufficient problems that CAR continued using manual BIFRS. The primary problem was that VIM-BIFRS was not capable of working within the open quantity remaining in the option year when generating new delivery orders. In addition, RutterRex significantly slowed down manufacturing of the test-bed shirt so the generation of the first new BIFRS generated delivery order was delayed for several months.

In May DSCP requested that CAR switch to making Air Force shirts to help with high priority backorders. This request was approved since VIM-BIFRS was not fully functional for testing. CAR continued to make about 100 shirts per week based on DSCP needs under the ARN contract because DSCP had not cut their "stand alone" contract. During this month DSCP cut the next 3-month delivery order for RutterRex and forgot about coordinating with CAR for the recommended quantities from BIFRS. DSCP did later accept BIFRS' recommended size mix and issued a revised delivery order based on this recommendation. However, this covered manufacturing requirements into November and effectively put the testing of VIM-BIFRS on hold. CAR followed inventory levels each month for this shirt and determined that the BIFRS recommendation was significantly superior to the original DO levels. CAR requested DSCP award a contract that included all 5 shirts RutterRex was making (Task 6) in order to complete the VIM-BIFRS research planned for this Task.

Once CAR completed the Air Force shirts and no contract was in place for other shirts, there was no basis for testing VIM-BIFRS or the paired production line concept. However, sufficient validation had been done and work accomplished in the commercial sector that CAR was very confident in both BIFRS and the paired production line concepts. It became clear during this time that the power of BIFRS is negated to a limited degree when new delivery orders cover long periods of time. However, the longer the time periods between generation of delivery orders, the more important is the balancing of the entire SC by item size.

A number of additional lessons were learned through Year 6 as we followed, in detail, DSCP's process for generating new delivery orders and worked with RutterRex on their exact delivery order needs.

The absence of interest expenses in military SCs diminishes the normal SC objective of minimizing inventories. A basic SC law is that large batches of orders or production requirements must have large downstream protective inventories to preclude stockouts while production lines are making lots of long supply items. Stated differently, transfer batch sizes must be reduced until all the costs of further reductions are greater than all the benefits. One of the major costs of large production batches in commercial SCs is large interest expenses for WIP in manufacturing as well as downstream in finished goods, distribution facilities and at customer locations. These interest expenses are not present in military SCs because the military does not pay any interest expenses and manufacturers do not pay interest on government furnished

material. Thus, from the standpoint of the military budgeting process and interest expenses, inventories and transfer batches of military items should be significantly larger than for comparable commercial items. They should also be larger from an operational standpoint. DSCP needs to carry larger inventories to provide surge requirements in wartime and to protect against extremely long procurement process and manufacturing delays.

Optimum delivery order frequencies. New DSCP delivery orders (DOs) should be generated about monthly to achieve a reasonable balance between administrative work and inventory investment. This takes into consideration that DSCP does not pay interest, downstream inventories should be very large to handle war-time surge requirements and end-of-year funding shortages, and generating new delivery orders can demand a lot of resources when done on too frequent a basis. Manufacturers need new DOs up to 90 days ahead of time when textile suppliers require firm DOs to begin their production. Manufacturers need new DOs about 6 weeks before they cut the first garments for the new orders. This allows ample administrative lead-time for running BIFRS, generating the DO, transmitting the DO, ordering labels, preparing markers, and starting the first cut. Once the system is in place and operating routinely, we could reduce this to about four weeks, and remove two weeks of inventory downstream. However, DSCP does not need to generate orders more frequently than monthly because the current policy of 135 DOS of wholesale inventory is more than sufficient to cover cutting new DOs every 60 to 90 days. Clearly, DSCP does not need to generate DOs more frequently than once every month, especially when they own the assets at the RTCs. This permits DSCP to have total asset visibility and to add another 45 DOS to their stockage targets and inventories.

Achieve inventory balance, but exercise care in drawing inventories down. More importantly, there is no driving need within the military budgeting system to reduce inventories. If one buying agency used advanced SC technology and concepts to reduce inventories to an operational minimum, they would quickly be at a great disadvantage in the competition for scarce funding. It would be better for DSCP to leave total inventory investments where they are and go after the first major objective of always being in stock. This is the "balance" part of BalancedFlow.

BIFRS must be run on a variable schedule to level plant workloads. Production plants schedule production in one of two ways. Manufacturers prefer to dedicate one static production line to each item. Dedicated lines provide for the highest overall product quality and lowest overall manufacturing costs. The alternative approach is to conduct item and/or line changeovers. These changeovers are required for small quantity runs or for alternating products to shorten production lead-times.

One of the three primary objectives of the BalancedFlow concept is to minimize the cost of manufacturing by eliminating manufacturing demand variations in both the short term (expedites) and long term (seasonal or budget-driven fluctuations). This means we want the dedicated production line to produce the same number of garments each day that the plant operates. This is a primary reason we created the annualized day of supply or ADOS rate – it is the level rate at which the production line should be running all year once seasonal inventories are properly established. In order to achieve level daily manufacturing, we have to convert annualized calendar day demand (the ADOSr) to production requirements per plant operating

day. For example an ADOS requirement of 100 items per calendar day becomes 146 items (365/250 * 100) per plant production day for a plant that operates 250 days per year.

The frequency of running BIFRS determines the total DO quantity. If we want to run it and generate a new DO about monthly, then we need to make it for about one month's supply based on the ADOS and our overall supply situation. Our overall supply target is the sum of our basic inventory objective (BIO) and the seasonal inventory objective (SIO) for the current week. The BIO is the sum of the wholesale stockage policy days-of-supply and the ADOS. For example, 135 days-of-supply times an ADOS of 300 items per calendar day equates to a BIO of 40,500 items. The SIO begins at 0 days-of-supply in December and reaches a peak of 100 days-of-supply in July. For 1 October, the SIO is 55 days-of-supply so the SIO stockage quantity is 55 days times 300 items per day or 16,500 items. Thus the total inventory objective or TIO for 1 October is 57,000 items. We would increase or decrease our ADOS ***slightly*** before we compute our new DO if we needed to increase or decrease supply chain stockage to bring it in line with our stockage target.

Each time we run BIFRS we have to compute the number of production days required to generate the quantity on the DO and count the days off on the plant calendar to determine (1) when to run BIFRS next and (2) the final delivery date to assign to this particular DO. So, for our example we want to generate a DO about once a month. This means we need to have 3,000 items (100*30) on the DO and this will support a BIFRS cycle of 20.5-plant production days or about 30 calendar days. Thus we have to count 20.5 plant production days into the future to establish the next date to run BIFRS.

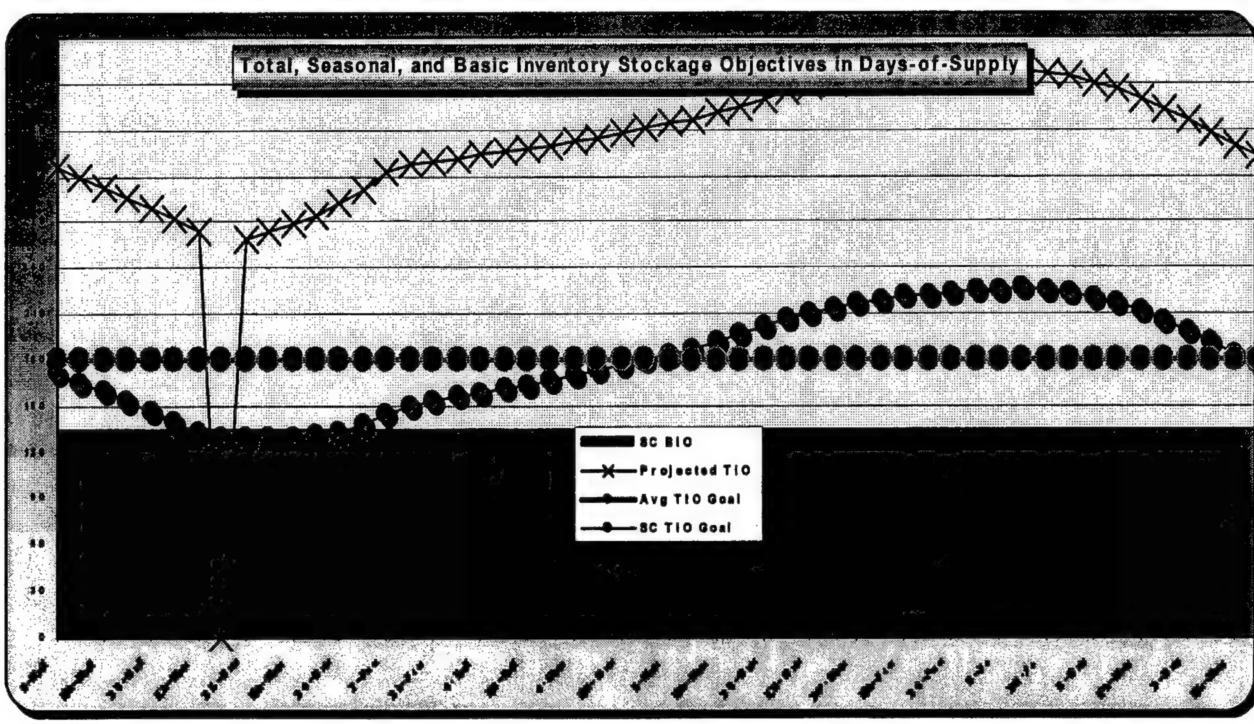
In addition, we have to add the administrative and pre-production lead-time plant days to our 20.5 BIFRS cycle days to determine the final shipment date for the DO. Each time segment has to be in production days so we could allow 3 days to run BIFRS and generate the DO, 15 days for the contractor to conduct the first cut, and 20 days for the first cut to move through sewing. Thus the final delivery date would be a total of 58.5 plant production days into the future for this DO. Ideally, to meet the manufacturer's requirement of level manufacturing, every 20.5 production days we would do a new BIFRS run, generate a new DO, conduct the first cut of a DO, and complete shipment against a DO.

Delivery Order quantities should be in multiples of "ideal" cutting batches. BIFRS was designed to optimize the efficiency and fabric yield within the cutting room because fabric is approximately 40 percent of the cost of goods sold. Cutting costs are minimized when as much fabric as possible can be laid and cut at one time. Each manufacturer knows the ideal cut size for each item. This is the sum of the maximum plies of fabric that can be cut at one time multiplied by the number of bundles that can be contained in one lay of cloth. The number of bundles per cut is constrained by the size mix, the length of the cutting table and the width of the fabric. For the AG 415 women's short sleeve shirt at RutterRex, this is 300 plies of fabric and 16 bundles per lay for a total of 4800 shirts per cut. Each bundle of 300 shirts has to consist of the same garment size, but every bundle can be a different size. VIM-BIFRS accepts values for the total DO quantity (plies times bundles) and the standard bundle batch size for cutting (300). The minimum DO quantity can be as little as one cut of 4800 shirts in our example or any multiple of 4800. If we want to run BIFRS about monthly and demand is about 10,000 shirts per month, we

should produce a DO of 9600 shirts about every 29 calendar days or go to 14,400 every 43 calendar days. BIFRS then re-balances the sizes in days of supply by allocating batches of 300 shirts at a time until the assigned DO quantity is reached.

Stabilizing plant workloads and optimizing cuts are too complex to implement. While the last two lessons learned are valid, the decision was made that they are inappropriate areas for Item Manager involvement at this time. Their time can be spent in other areas that will generate much greater improvements. Thus, BIFRS will not generate level manufacturing requirements and ideal DO quantities will remain as full-case multiples. This area should be revisited once all the other improvements such as inventory balance are achieved.

Managing the seasonal nature of demand. Extensive research efforts were required to develop an algorithm to handle the seasonal nature of demand. The following chart shows the first application of this algorithm as applied through BIFRS to the AG 415 shirt's SC. Much later after studies of many different items, the conclusion was reached that the same algorithm can actually be used for all recruit items of all Services because demand over time in days of supply is driven only by the arrival pattern of new recruits and this pattern is so similar for all Services that one model shown below is sufficient for all dress items. The same model can be used for field clothing by shifting the peak demand week 45 days earlier than the peak demand week for dress clothing.



Days of supply (DOS) are shown on the left in 30-day increments and weeks of the year are on the bottom of the chart beginning with the first week in the FY. The basic inventory objective (BIO) is the 135 DOS stockage policy and is shown in solid green. The annual average total inventory objective (TO) is shown as a straight line of dark green circles set at the policy level of 180 DOS. The seasonal inventory objective (SIO) is shown in light green circles above the BIO. The weekly TIO is the sum of the BIO and SIO for each week. In this case, we had to suppress the computed SIO and annual average TIO by 6 DOS to meet the 180 DOS policy requirement. This suppression can be

seen on the left of the chart where the SIO penetrates the BIO for several weeks by up to 6 DOS. This penetration is of no concern at these large inventory levels, but would be important if we were trying to minimize inventories and avoid stockouts. The higher the downstream stockage policy levels, the less important is the penetration of the BIO.

The Projected DOS on-hand based on requirements from the next 3-month delivery order and current inventories and current on-hand inventories are shown by the line of x's at the top of the chart for our AG 415 shirt SC. (The assumption is made that all sizes are balanced in days-of-supply because this chart is for all sizes of one PGC.) The weekly posting that goes all the way down to 0 DOS represents the "0" seasonal inventory week and starting point for all surge calculations. To summarize this chart, we are locking the TIO at the 180 DOS policy level and forcing the BIO plus SIO components to average the TIO for the year. The projected TIO at the current delivery order requirements rate shows that this SC will continue to be approximately 5 months over stocked (again, assuming all sizes are balanced in DOS).

Item Managers are not capable of balancing inventories and eliminating all stockouts with available tools and policies. Thus, Item Managers actually need to carry much more excess inventory to reduce stockouts unless we change the tools and policies to eliminate the underlying causes of the stockouts. The military does not have a unique lock on this problem. Everyone in both commercial and military SCs uses these standard replenishment tools and policies -and everyone gets the same unsatisfactory results. Software tools and management policies were designed many years ago to accommodate standard cost accounting and were never updated to accommodate the two core SC problems of variations in demand and customer wait times (CWTs). Discussion of these core problems and the BalancedFlow solutions are continued following the presentation of the customer wait time status at Parris Island below in Task 2.

3.2 Task 2 - Parris Island Inventory and Cost Reduction

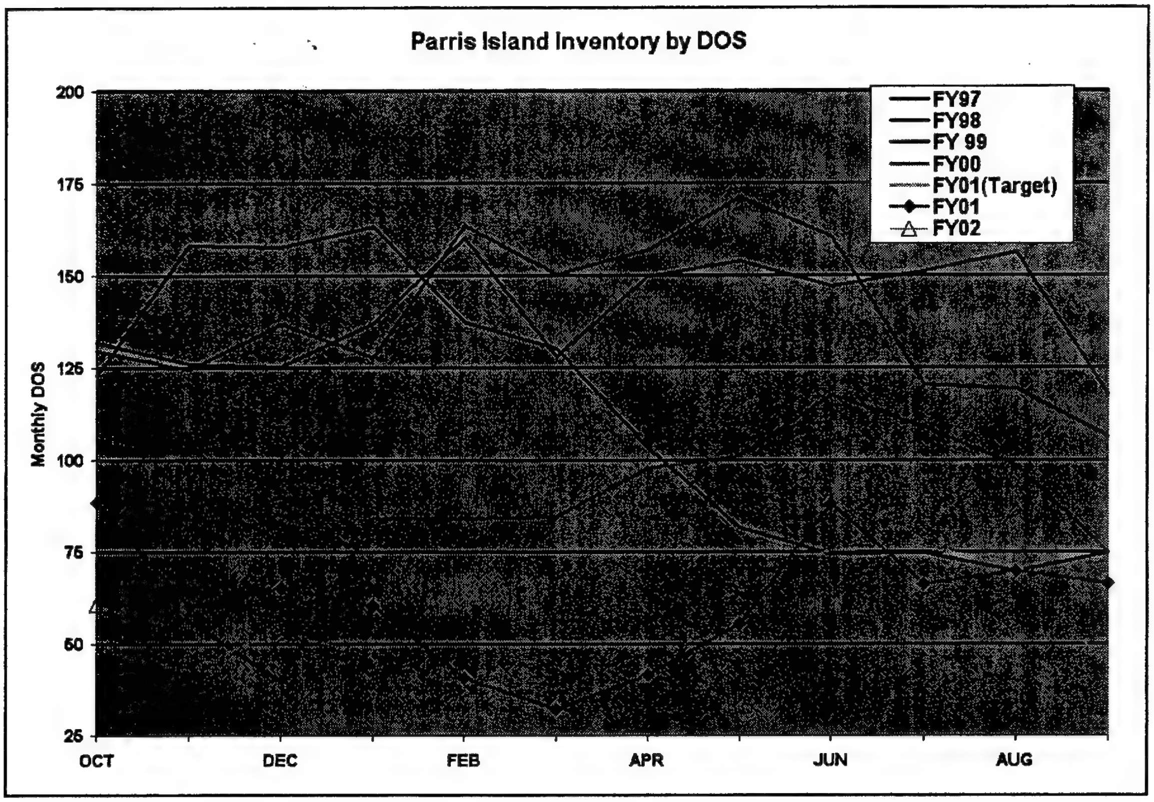
Purpose: Track Parris Island inventory levels, track the performance of Vendor Park Southeast support of Parris Island, and maintain BIFRS software at Parris Island.

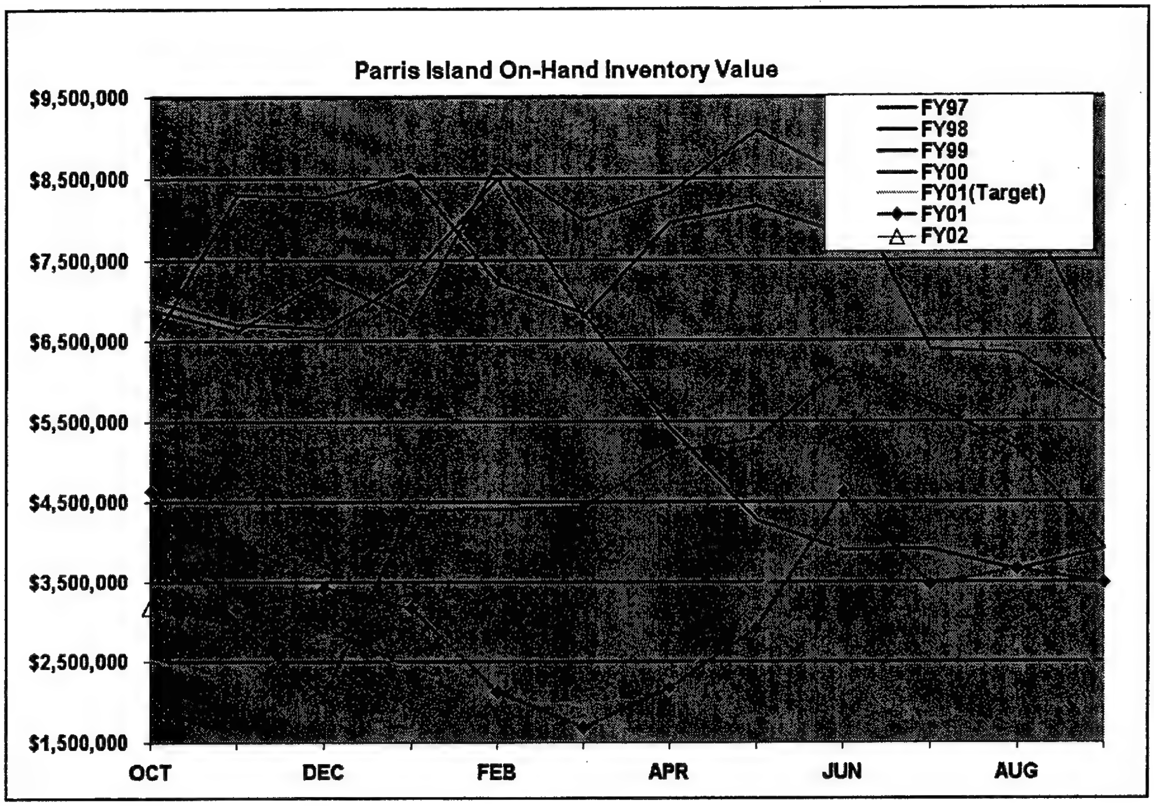
Original Task: Monitor inventory levels and replenishment times at Parris Island, update the ARN Inventory Charts monthly, and provide programming assistance if there are any problems with the CAR-installed BIFRS software.

Status: CAR installed BIFRS-R and BIFRS-DSS at Parris Island prior to Year 6 for Parris Island to use to manage inventory replenishment. BIFRS-R replaced the standard replenishment module of MUMMS and BIFRS-DSS provided managers the ability to set dynamic stockage objectives for all storage locations based on expected recruit arrivals and gave item managers total visibility of order status on a single screen.

The following DOS and Value charts document the monthly success of the use of BIFRS at Parris Island. Inventories were tracked in this manner through the end of Year 6 when QLM-Local installation commenced. Figures for FY 97 and 98 show the status prior to the use of BIFRS. The FY 99 line clearly shows the point in January when Parris Island began to draw inventories down. Significant progress continued through FY 00 and FY 01 (Years 5 and 6). In addition to these high inventories, the initial stock out rate was an unacceptable 4 percent. By the

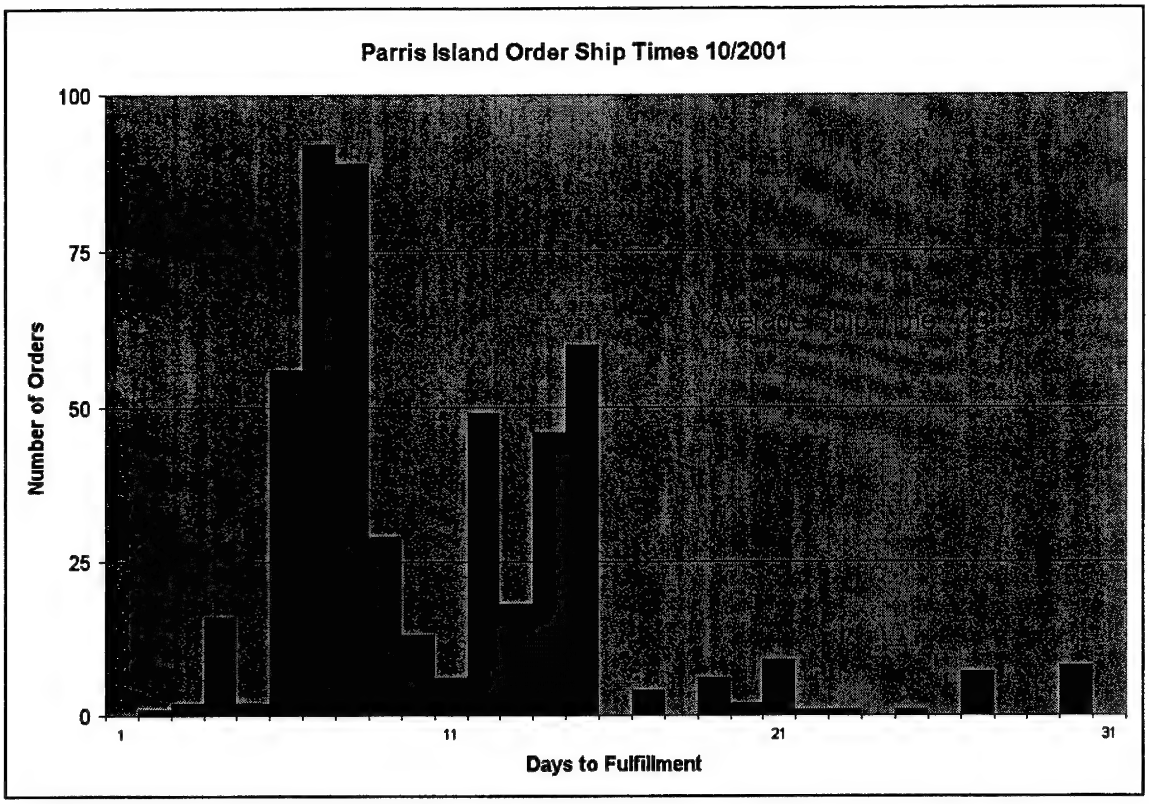
end of FY 99 there were virtually no stockouts and every recruit graduated with a complete compliment of uniform items.





One of the two core SC problems is the variation in customer wait times. As discussed earlier, one of the two core SC problems is Murphy or the variation in customer wait times (CWTs). This is also known as order ship time (OST) and replenishment lead-time (RLT). The FY 01 Target lines were generated by BIFRS-DSS and all deviations from it were intentional on the part of Parris Island. At the lowest inventory point in March, Parris Island had mastered the BIFRS techniques and actually could have operated at one-half of the inventories shown from that point forward. However, they chose to carry higher inventories because replenishment lead-time variations were not within statistical control. This demonstrated one of the two most vital SC lessons learned – variations in customer wait times must be brought under statistical control to minimize both stock outs and inventory investment. This variation is the core problem – not the average time as normally assumed.

CAR tracked customer wait times monthly through Year 6 as shown by the following snapshot for October:



The second of the two core SC problems is the variation in customer demand. Parris Island was running BIFRS-R weekly and generating replenishment orders for all items for which the thresholds of minimum order quantities had been reached. This was the key to all inventory reductions to date – large batches of infrequent orders simply had been converted into a weekly flow of orders in full case multiples. By this time the new Vendor Park Southeast was making routine replenishment shipments weekly. Emergency shipments were made as required, but emergency requirements had also been reduced drastically by BIFRS-R.

During the year average CWTs ranged from 7 to 15 days. In the chart there is a clear cluster of arrivals around 7 days and another smaller cluster around 14 days. These were associated with the arrivals of the weekly shipments from VP SE. We cut the chart off at 31 days because only a very few orders (less than 5 percent) fell beyond this point each month and we believed these were insignificant. At this point we felt we had done everything possible to minimize stockouts and inventories at Parris Island. Early in Year 6 we realized a lot more work was required to eliminate the non-random variations in CWTs and customer orders. ***We learned the very few late receipts not shown above were more significant than the timely receipts shown in the chart.***

The specific problem is that a very few replenishment orders continued to fall to the right of the average OST in the above chart. In fact, a very small percentage still required 90 days or longer to be filled – primarily because of contracting failures. Most of these were for female items so Parris Island set stockage targets much higher for all female items than male items. This helped significantly and was the final significant action that Parris Island could take to help themselves. We considered running BIFRS daily to produce a better flow of replenishment orders, but it made no sense to do this when deliveries were only being made weekly. (We later realized many

companies who have implemented Lean Manufacturing and one-piece-flow have actually fallen into this same type of non value-added practice. Generating new requirements more frequently than downstream inventory status is updated or more frequently than movement of product occurs results in excessive operating expenses with no bottom line benefits.) The next step in improving SC performance for Parris Island had to be taken by DSCP.

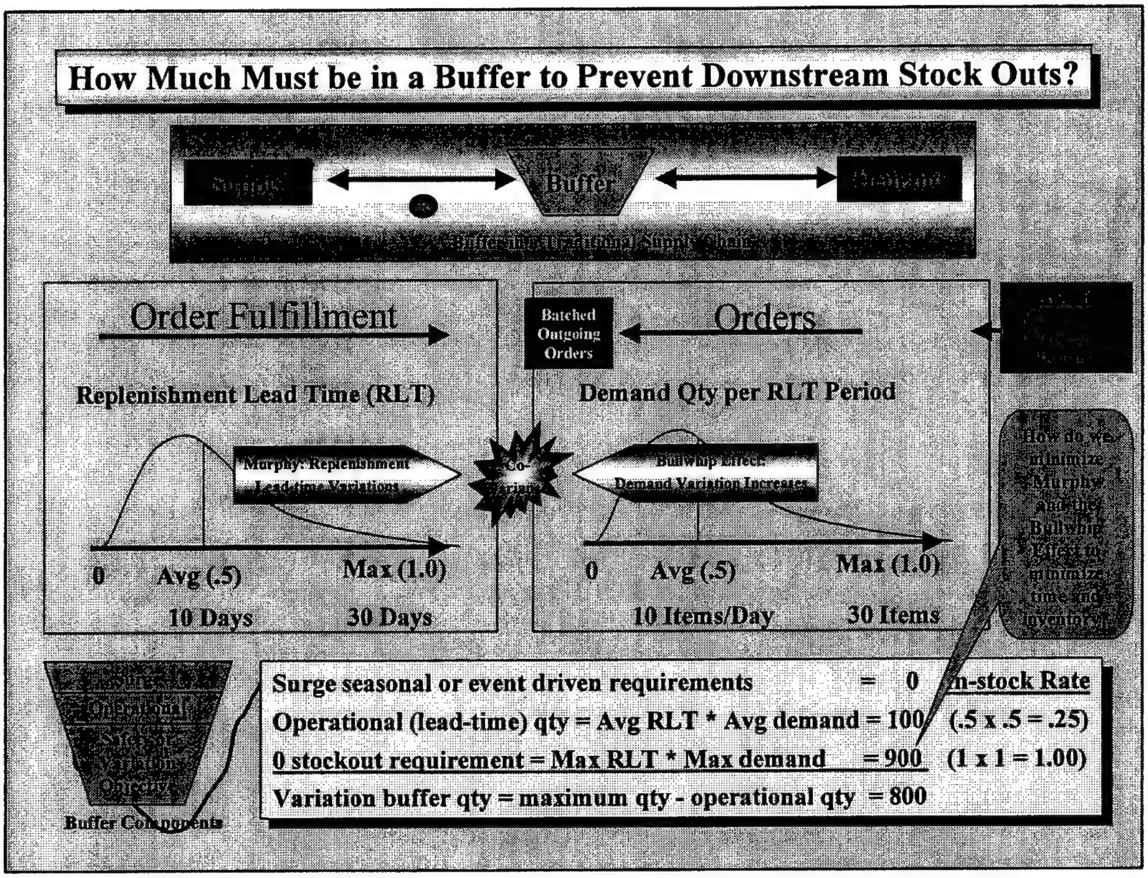
Theory of Constraints, Lean Enterprise, and Six Sigma process improvements. CAR began constructing the BalancedFlow supply chain solutions in 1996 based on the theory of constraints (TOC) and Lean Enterprises (Lean) because we had been so successful employing these concepts on the manufacturing floor. In 2000 we tested our work against the Six Sigma management concept. This immediately re-validated, but in a much clearer fashion, the two core problems that we had begun to address to radically improve any supply chain.

The Six Sigma approach begins with the universal assumption that product and process variations are the core causes of all business problems. This is also the underlying foundation of total quality management (TQM) and Deming approaches to perfection. The Six Sigma steps are to (1) identify the sources of process and product variations, (2) measure the variations, (3) determine which variations are causing the most negative impact on the bottom line of the business, and (4) employ world-class tools to eliminate these variations. Variations brought on by products themselves are normally unique to specific products and are not common to all SCs. On the other hand process variations in the form of how products are ordered and moved from transformation process to transformation process have nothing to do with how products are physically transformed and thus apply to all SCs. Our BalancedFlow focus is specifically on SC process variations rather than product variations.

The two core SC process problems are Murphy and the bullwhip effect. The two core SC execution process problems are process variations as predicted by Six Sigma. They are the variations in customer demand and customer wait times. In more recent literature these are commonly referred to as the bullwhip effect and Murphy.

The bullwhip effect begins with the repetitive batching of orders as demand moves sequentially up the supply chain from the consumer. At each level "adjustments" are made sequentially based only on some type of forecast and very limited inventory visibility. This results in alternating waves of stock outs and oversupply moving down the supply chain as well as huge swings in manufacturing demand.

Murphy is specifically the variation in replenishment lead-times (RLTs) that accumulates as products move down the supply chain to the consumer. Inventory in the form of buffers is required to prevent downstream stock outs. The amount of inventory required is determined primarily by the RLT and secondarily by the demand. However, it is not the average RLT or the average demand that causes large stock outs and high inventory requirements, but high variations in RLT and demand. From a statistical viewpoint, this is a state of co-variance in which the variations in RLTs drives variations in demand, which, in turn, drives variations in RLT. The following figure shows how this works:



All supply chains are in a perpetual state of co-variance as shown above. We can start anywhere in the co-variance cycle, but basically the variation in demand from large, infrequent customer orders results in variation in RLTs that, in turn, results in larger orders less frequently. This cycle has to be broken and both variations eliminated for optimum SC performance. No one other than the ARN is even beginning to approach this today in commercial or military supply chains.

By the time we applied the Six Sigma process to our work, we had identified both core problems and had addressed each to a significant degree. BIFRS-R was highly successful because it significantly reduced the bullwhip effect. We felt we could reduce inventories no further at Parris Island unless we reduced OSTs (Murphy) further. We did not realize at first just how critical this was. By this time we had suggested repeatedly that DSCP should begin internal projects to cut the right tail off the OST curve for Parris Island.

We must reduce the variations in RLT <u>and</u> customer demand <u>across the entire SC</u> in order to minimize stock outs, reduce inventories, and level manufacturing demand <u>- at the same time</u>. The third lesson was that we had to repeat the elimination of Murphy and the bullwhip effect up the entire SC and we had make the sequential passing of demand immediate all the way up the SC to achieve optimum SC performance. We found this approach to be totally new. There were no models or information systems to apply so we had to build our own.

Over the past 5 years CAR and other Clemson researchers studied over 50 commercial supply chains to determine how they compare with and differ from military clothing SCs. We were

surprised to find the very same issues and low levels of performance in all SCs. The companies that had applied some type of Lean Manufacturing internally had made significant, but not extraordinary improvements. None had really done anything significant or non-traditional with customers or suppliers and only one had even thought about doing something SC wide. It was obvious the application of BalancedFlow would make extraordinary improvements in all the SCs we evaluated.

Our research over the years has found no instances in which two or more SC partners have ever undertaken the elimination of both of these variations. Seldom have two partners attempted to work together to eliminate even one of them.

Companies do not collaborate for their mutual benefit. Through literature and seminar research, we identified the two major barriers to supply chain optimization. Understanding Murphy and the bullwhip effect is the first major barrier. The lack of collaboration (and collaboration tools) is the second major barrier. There are three primary reasons for not collaborating:

> First, companies do not realize the benefits that are available if they worked together as if they were one company, they do not know how they would work together, and they are afraid they would lose competitive advantages if they did work together.
>
> Second, everyone is comfortable with existing systems, but existing systems are a major part of the problem! They were designed to address cost accounting, to conduct push scheduling, to launch large production batches for low manufacturing costs and to generate large batches of replenishment orders infrequently. No one even thinks of business interchange beyond one level up and one level down from where they stand in the SC. Even if they do, there are no existing systems like BalancedFlow that reach across more than two SC levels. (Lean Enterprises has structured value stream mapping as an approach to thinking across extended SCs in the past 4 years, but each SC has to build its own unique solutions.)
>
> Third, it takes "enlightened" senior leadership for a company to move away from standard practices in order to achieve extraordinary results. Only a very small percentage of all companies have implemented non-standard practices such as Six Sigma, TOC, or Lean within their own walls. Everyone believes the answer resides in "better" standard systems. However, only about 16 percent of all major information system implementations achieve the expected results and it takes years to implement these systems. It is no wonder the inertia to avoid trying something drastically different is so strong. Finding two "enlightened" companies who are willing to set upon this kind of journey adjacent to each other in a single SC is virtually impossible.

Neither standard systems nor BIFRS can completely optimize the performance of C&T supply chains. In contrast to standard practices and systems, the ARN's BalancedFlow SC concept is a radically different approach. It was designed over the years to minimize both the RLT and demand variations. However, even fully implemented BalancedFlow military SCs with their large wholesale inventory buffers will not establish total confidence in the SCs because a few very long RLTs will still exhaust the large policy buffers and result in retail stock outs.

DSCP experiences these few long RLTs and backorders because of the nature of the government's procurement system and the uniqueness of military end items and components. It is virtually impossible for DSCP to keep all items in stock all the time and DSCP's customers will have a few long-term stockouts. These few un-avoidable shortages, in turn, are directly responsible for excessive inventories and the majority of all backorders. This occurs through a series of sequential financial, contractual and logistical events in a manner that makes it difficult to associate the large inventories and stockouts with their causes.

First, DSCP's retail customers set their inventory stockage targets according to historical CWTs. Customers such as RTCs cannot accept any stockouts so they try to set all target levels high enough to cover the longest possible CWTs. This is why the RTCs were initially stocking over 150 days of supply even though the average OSTs were about 30 days. This large retail stockage, in turn, causes the next problem of large wholesale inventories and backorders. The specific cause is that all retail replenishment programs generate fewer, but larger replenishment orders as on-hand inventories are increased. Thus, the bullwhip effect is constantly initiated by these batched orders.

Next, DSCP has to carry very large inventories in order to satisfy large orders from multiple customers at the same time. The current policy is to carry an annual average 180 days of supply of recruit items at wholesale, but a year or more of inventory is very common because 180 days of supply is just not sufficient to avoid shortages. Stock outs and backorders are the visible result of these relative few long RLT items. Large inventories cannot solve the backorder problem because DSCP continues the bullwhip effect up the supply chain where end-item, component, and raw material manufacturers live with "feast or famine" situations. Delayed deliveries from upstream partners then result in stockouts at the wholesale level and the cycle continues. This cycle must be broken, but standard systems and policies cannot be used to break it because they are primary contributors to it.

As shown in the above charts for Parris Island, CAR demonstrated the power of converting large batches of infrequent orders into a flow of small orders at Parris Island prior to Year 6. This same solution was suggested to the Army for their RTCs, but they were not convinced it was the solution. About this same time the Army initiated a request for DSCP to assume ownership of their RTC inventories. This provided DSCP with the means of establishing a policy of replenishment flow rather than large replenishment batches for the Army RTCs. New ARN systems were designed to permit a flow of orders, but retail and wholesale managers returned to large batches of orders to minimize budget-driven replenishment actions and inventories began to grow again.

It is most interesting how all SC players view the symptoms of Murphy and the bullwhip effect because they do not understand the underlying causes. The military is no different. On the surface, downstream supply chain people blame upstream supply chain people for stockouts. This can be described no better than the words of one RTC manager who stated "if DSCP would just fill my requisitions when I submit them like they are supposed to do, there would be no supply problems." We learned that downstream SC partners have no idea that the manner in which they place replenishment orders determines to a significant extent the on-time delivery rates and costs of their items.

Upstream partners know that they have to respond to downstream orders and feel that downstream partners could improve the ordering process somewhat, but have no idea of how devastating standard replenishment systems are on everyone in the SC. And they feel the same way about their suppliers that their customers feel about them. At best, all partners realize SC problems are not caused by the people in the SC, but are a product of the existing systems and policies.

However, these fixes including BIFRS, even if/when properly implemented, will not prevent the last small quantity of long-term RLTs and their resulting retail stockouts. We must break the co-variance cycle completely by eliminating these last few long CWT items.

The specific problem is that these few items cannot be known ahead of time so wholesale and retail item managers must carry extra inventories of all items. This puts us right back into the co-variance cycle described above and we know that neither standard systems nor BIFRS can break the cycle completely.

No efforts were launched within DSCP to address Murphy. However, CAR continued to identify solutions to eliminate both variations and integrate them into BalancedFlow. Eventually about 15 individual solutions were used. CAR also identified and proposed for Year 7 the demonstration of a promising new commercial concept named Paired Production that could be used to eliminate these few extremely long supply failures and completely break the co-variance problem. This is discussed in detail in Section 4.

3.3 Task 3 - Parris Island Management Tools

Purpose: Define the functionality of management tools developed by CAR for Parris Island that will be of value to Parris Island and other RTCs under QLM-Central.

Original Task: Compare the management tools developed by CAR for Parris Island with those available through QLM. Provide functional descriptions and algorithms to PDIT of any required tools that are not present in QLM-Central so they can be added as VIM tools. Assist PDIT in including the tracking of OSTs from Task 2 as a VIM tool.

Status: The ARN partners determined QLM-Local either had or could add all the vital features of BIFRS-R, BIFRS-DSS, and local programming CAR had accomplished at Parris Island. BIFRS-W had been split out of original BIFRS and was being implemented as a stand-alone module (VIM-BIFRS) to generate manufacturing delivery orders as part of VIM.

The decision was made that Parris Island would retain BIFRS to manage clothing items that were not obtained from DLA because it was not appropriate for the ARN to fund local Service projects.

Lessons Learned: The major SC lessons learned were moving forward for implementation through other ARN projects. QLM-Local was designed so a flow of replenishment orders could

be generated and DSCP was acquiring ownership of RTC inventories so they could institute a policy of flowing replenishment stocks into these RTCs. BIFRS-W, when implemented as VIM-BIFRS, would generate a flow of manufacturing orders rather than the historical infrequent batches. Finally, Paired Production was to be evaluated as the final solution to bring customer wait times under statistical control.

3.4 Task 4 - Parris Island License Plate Program.

Purpose: Demonstrate the use of pallet and case-level license plates to reduce lead times and operational costs while improving stock rotation.

Original Task: Assist Parris Island in the expansion of the license plate project by using the license plates that Lion Vallon attaches to cases as they pass through Vendor Park Southeast. Streamline receiving procedures and supporting software at Parris Island.

Prior to Year 6 CAR had established a local license plate program to assist Parris Island in managing and rotating inventories. This task was approved for CAR to expand the local license plate program to the ARN SC by using the license plates generated by VP SE.

The decision was made to commence this task after QLM-Central was in place to preclude working with Parris Island's current legacy systems and then having to interface with new Arn systems. Determinations were later made that QLM would not interface with any license plate system and it was not feasible to use a local license plate system at any other locations. This task was then terminated because it was inappropriate to fund local Service projects with ARN funding.

Lessons Learned: Research indicated license plates are becoming standard practice in firms practicing advanced logistics. They improved stockage rotation and inventory control at Parris Island while reducing operational resource requirements. However, if inventories can be maintained at a very low level at retail once DSCP takes over ownership, license plates will have less value at RTCs.

3.5 Task 5 - BIFRS-W Implementation for all Four Army Green Shirts.

Purpose: Test and expand the roll out of the BIFRS-W beyond the Demonstration Centers.

Original Task: By using ASAPWeb and VIM-BIFRS, CAR will place all manufacturers of Army Green Shirts on BIFRS in conjunction with DSCP Item Managers and PDIT. This will begin with CAR's shirts for Ft. Leonard Wood as soon as BIFRS-W is available as a VIM tool. This task enables CAR to roll out BIFRS to initial contractors and provides the test-bed required to expand the BalancedFlow concept upstream to the first textile supplier.

Status: Year 6 began with CAR using local BIFRS to schedule one of four Army Green shirts for CAR and RutterRex as discussed in Task 1. The other shirts could not be added because DSCP was not able to get the contractors to participate in VIM-ASAP (formally ASAPWeb). In

addition, higher priorities precluded PDIT from expanding the scope of VIM-BIFRS to handle multiple PGCs and making other fixes identified earlier.

CAR was able to test VIM-BIFRS by using it to test the generation of delivery order requirements for each of the five shirts RutterRex was making. Since manufacturers' inventory data was not available through VIM-ASAP, CAR obtained it directly from RutterRex and used the SAMMS Data Warehouse for the source of wholesale data.

CAR developed an Excel Workbook and instructions for computing new DO requirements that optimized level manufacturing and cuts. However, the decision was made to terminate this part of BIFRS-W because it was too complex for Item Managers and their time could be better used for higher priority work.

CAR learned that VIM-ASAP did not capture all the data necessary for VIM-BIFRS. Two versions of the VIM-BIFRS calculations are required to generate all new delivery orders. First, if an item is in adequate supply status, we can assume all open DOs are WIP and simply generate the next DO to re-balance the entire downstream SC and move the total on-hand position closer to the target level for the downstream SC. Thus the inventory data within VIM-ASAP is acceptable and this is the most frequent situation.

However, if an item is in short supply status, we need to know what has been cut and what remains "open to cut." This "open to cut" quantity at the NSN level is available for BIFRS to re-allocate to shortage NSNs. VIM-ASAP does not break the inventory out in this manner.

CAR made recommendations for modifying VIM-ASAP and VIM-BIFRS to accommodate both situations.

This task was combined with Task 6 during Year 6 and they together became new Task 2 for Year 7.

3.6 Task 6 - BIFRS-W for Additional DSCP Directed Garments

Purpose: Roll out BIFRS-W to reduce retail stockouts, reduce inventories, and reduce expediting at DSCP and at contractors.

Original Task: CAR will function as a wholesale item manager and, in conjunction with DSCP Item Managers, extend BIFRS to selected manufacturers beginning with all the shirt contracts awarded to RutterRex. Different methods of using the output of VIM-BIFRS will be tested to determine the optimum procedures for implementing its manufacturing recommendations once the initial implementation is stabilized.

Status: This task was originally intended to follow-on once VIM-BIFRS was operating fully in Task 5. With the Program Manager's approval, this task was initiated as a substitute for Task 5 in October and November as discussed in Task 5. It was then rolled into Task 2 for Year 7.

In June DSCP requested CAR evaluate putting the new Coast Guard boots on VIM-BIFRS. CAR conducted a detailed study of the supply chain and operational capabilities of the existing manufacturing and Coast Guard systems. It was clear that BIFRS would be an ideal tool to use in the initial fielding of new items because limited manufacturing capacity is almost always used for the wrong items (mostly low demand) early in the new fielding process. This delays customer satisfaction significantly and the excess low demand items tie up retail and wholesale funds for many years. BIFRS would tie fielding needs directly to manufacturing and eliminate this problem. However, no response was received from DSCP and the initial delivery order was generated without using the BIFRS process.

Lessons Learned: BIFRS would be an ideal tool to use for fielding new items faster, for higher customer satisfaction, and for lower investments at retail and wholesale. Other lessons learned are summarized at Task 5.

3.7 Task 7 - BIFRS-W for the AG 415 Fabric Manufacturer

Purpose: Conduct the research to extend the BalancedFlow supply chain upstream to textile manufacturers in order to reduce backorders, keep manufacturing flowing, and enable surge capabilities.

Original Task: The Army green shirt supply chain will be extended upstream to include Dan River, the manufacturer of the shirting fabric, after complete supply chain visibility is established. CAR will work with DSCP and the textile manufacturer to minimize all costs and unintended inventories while determining optimum requirements for creating surge stocks. Methods will be identified and developed to eliminate all barriers to having a low-cost flow of textiles to the end-item manufacturers. Dan River has agreed to participate in the project.

Status: This Task was not completed in Year 6 because all four shirts were not added to VIM-BIFRS as discussed above. In addition, RutterRex added Russell as an additional fabric source so we had two suppliers of this fabric and that complicated the task. However, based on associated research in commercial supply chains, it become clear that computing the upstream fabric requirements would be straightforward once VIM-BIFRS was working. The challenge will be in determining what data is required, who will provide it, and how will it be provided.

This Task was also rolled into Task 2 for Year 7. In addition, rolling BIFRS out to an entire SC became the basis of CAR's NOMEX SC proposal for ARN II.

Lessons Learned: A major breakthrough in the BalancedFlow SC concept in Year 6 enabled the extension of the BIFRS concept and software beyond a single manufacturing line to entire SCs with no addition in complexity from the SC partners' perspectives. This was the invention of SC Sections that break the entire SC into as many sections (real or virtual) as necessary for total flexibility and simplicity from a data management standpoint.

3.8 Task 8 - Manufacture all Special Measurement Shirts for DSCP.

Purpose: Create and demonstrate a complete special measurement software and manufacturing system that DSCP can export to commercial manufacturers.

Original Task: CAR has been awarded a separate contract from DSCP to manufacture all 24 SM dress shirts for DSCP. The ARN contract funded the setup of some of these shirts during Year 5 and this task funds the setup of the remainder early in Year 6.

Status: All ARN-funded set-ups were completed in March. Service members received all SM shirts on time with the exception of a very few Navy shirts that could not be set up until early in Year 6 because the Navy changed the patterns to accommodate athletic and classical fits. The decision was made to wait on these new patterns to be developed before setting the Navy shirts up for special measurement production.

The manufacturing and delivery of special measurement shirts (in conjunction with the EOF software discussed next) reduced customer wait times from an average of 77 days to less than two weeks and reduced the actual contractor's costs from about $120 per shirt to about $45. As a follow on to this success, CAR proposed fully automating the complete special measurement marker process and adding the first non-shirt pilot item as Task 4 in Year 7.

Lessons Learned: Extensive experience with the set up and operation of these systems resulted in a large number of operational and technical improvements to the initial systems. A proposal was made to extend these improvements to a stand alone software package and the first special measurement item beyond dress shirts in Year 7.

3.9 Task 9 - Upgrade EOF Data Entry Capabilities.

Purpose: Provide EOF users with low-cost, remote data entry capability that includes on-board error checking and replace obsolete manual ordering forms.

Original Task: Develop software to allow EOF to run on low cost, portable devices for high schools, clothing sales stores, and RTCs. State-of-the-art portable devices will permit on-board error checking while collecting measurement data at remote sites. This system will be developed and tested with input from one high school, RTC, and clothing sales store. CAR will also assist DSCP in replacing obsolete manual SM ordering forms with new forms that contain all required measurements. CAR will also explore expanding the EOF Internet capability to permit Services to originate EOF orders at one location with measurements and complete the order with ordering information at a second location.

Status: Once CAR began manufacturing all SM dress shirts for DSCP, the continued use of the manual SM ordering forms became a major problem. The old forms could not be eliminated primarily because the EOF only contained recruit clothing items. CAR's initial research found that over 30 percent of manual orders had fatal measurement flaws. Experienced patternmakers could catch about half of these and the remainder could only be detected when the garments were

returned because they would not fit properly. Since the old forms could not be withdrawn from circulation, most ordering offices continued to use them even when the EOF ordering was available.

The old forms presented two specific measurement problems. First, the manual forms did not contain the "across the shoulder" measurement for male and female shirts and the "upper chest" measurement for females. These measurements were introduced in the EOF because they are both vital to making upper body garments that fit properly.

In addition, the Army and Air Force did not permit JROTC units to submit orders directly. They had to initiate the manual forms and send them to designated ordering offices for completion. When the Air Force saw the value of the EOF, they immediately changed the policy for their JROTC program to take advantage of the EOF, but the Army would not change their policy.

CAR could not begin to manufacture SM shirts when vital measurements were missing or clearly incorrect. CAR at first called the ordering officers to obtain the missing or correct data, but this took too long and CAR was not funded for this work. DSCP finally agreed to conduct quality checks of all manual forms and complete all missing data before sending the orders to CAR. This resolved most of CAR's problems by shifting the workload to DSCP and the customer wait times were still unacceptable.

In July CAR hosted a DSCP-called meeting of SM representatives from all Services in which we determined that the original task of creating software for initiating requisitions on portable devices was not the solution to expanding the use of the EOF. The meeting was well attended and the use of the EOF increased significantly after the meeting.

CAR provided many user-friendly improvements to the EOF in Year 6, but this Task was modified significantly to meet all the needs identified at the July meeting. Year 6 ended without sufficient funding to begin the expanded EOF Task. This became Task 3 for Year 7.

3.10 Task 10 - CAR Translator (CART)

Purpose: Fully automate the links between the DataMart and contractors' legacy systems while eliminating the need for DAMES and EDI transactions. Improve the quality and timeliness of data transactions while lowering the administrative costs significantly.

***Original Task*:** A program will be written to automate fully the transfer of all transaction data between the DataMart and the contractors. The program will use all methods of communicating (manual, EDI, DAMES, ASAPWeb, or fully automated) as specified by each contract and will eliminate the requirements for EDI and DAMES. CAR will coordinate with PDIT to ensure all data are included and the most efficient means possible are used to transfer the data.

Status: CAR completed this task early in Year 6. However, PDIT undertook this same task in Year 6 by working with Peckam. This consisted of an Web-based capability that could be used by all manufacturers once it was completed for Peckam. Therefore CAR's software was not

needed or deployed to other manufacturers. CAR used in locally to support its own manufacturing and to connect new delivery orders electronically to ARN-AIMS and shipments to SAMMS.

3.11 Task 11 - Optimize Replenishment Costs

Purpose: Provide Wholesale Item Managers a tool to minimize total replenishment costs

Original Task: CAR will begin a project in Year 6 to develop software and demonstrate the capability to minimize total replenishment costs. The software will recommend replenishment strategies and actions to operate the distribution systems with the lowest possible distribution and transportation costs. For example, transporting and handling small quantities costs more per item than large quantities. However, moving small quantities reduces inventory requirements. This system will find an optimum trade-off based on parameter values. Inputs will be the flow of product into the system by contract and location, alternative distribution and transportation methods and costs, and demand by location and time. Outputs will be optimum inventory locations, inventory levels, distribution methods, and transportation methods. A by-product of this task will be a model for managing shortages or backorders within the distribution system. This model will use the most advanced concepts to flag situations for computer-assisted Item Manager intervention to minimize stock outs and Item Manager time requirements.

Status: CAR used the lessons learned in developing the decision support system software for BIFRS at Parris Island as the starting point and completed a mathematical model that determined the optimum inventory levels and batch sizes for a supply chain section. However this model proved too complex and we had to start over with a simpler model that would generate an acceptable solution rather than the complex model that would generate the optimum solution.

At this same time we developed the SC Section concept discussed earlier for BIFRS and realized this was the key to simplification of the SC and it would enable a much simpler decision support solution. In addition we also learned BIFRS was an ideal backorder management tool.

CAR completed the development of a prototype decision support system that ran in a reasonable amount of time. The calculations are done by a Visual Basic program "behind the scenes." The objective of this system was to assist item managers in minimizing operational expenses and maximizing throughput while eliminating retail stock-outs. The system considers the trade offs between costs and response times. It can handle any number of locations in a supply chain and multiple products. We tested the system using a spreadsheet for inputs and outputs

To set up the system one enters estimates for SC parameters such as the cost of holding inventory, changeover costs at the manufacturer, and the cost of handling each process or transfer batch. The system calculates recommended inventory target values at the manufacturer, the distribution center, and the retail location. The model only handles linear supply chains but can be scaled up to handle multiple retail sites.

A Year 7 proposal was made to scale the model up and purchase software that was designed to run this type of model.

Lessons Learned: Determining optimum order, make and transport batch sizes and inventory stockage targets for multiple retail and wholesale locations is a very complex undertaking from the computational standpoint because of all the variables. However, the starting points for the two most important computations, optimum buffer and transfer batch sizes are rather straightforward:

> Retail and wholesale buffers have to be large enough to accommodate the largest possible combinations of Murphy and the bullwhip effect when they occur at the same time.
>
> Ordering, shipping, and manufacturing transfer batches should be reduced in size until the costs of handling additional batches exceeds the downstream benefits. For military items interest expenses are neither a cost nor a benefit because interest is not paid by the military like it is in commercial SCs.

Current DSCP stockage levels are much higher than current stockage policy levels, but not high enough to eliminate all stockouts because of the requirements of government procurement policies and the use of standard replenishment systems at retail and wholesale. The best approach to this problem is to implement BIFRS and use it first to create balance in days-of-supply within and across supply chains. Then, careful consideration should be given to reducing inventories. This should be evaluated with extreme care because of all the disadvantages of reducing inventories given the military budgeting system. In addition, the only way to effectively reduce inventories is to reduce manufacturing significantly and this could decimate the fragile industrial base.

3.12 Task 12 - Baseline and Evaluate 3D-Body Scanners

Purpose: Provide information upon which Services can determine the feasibility of using scanners in the recruit issue process and other locations to obtain body measurement data.

***Original Task*:** CAR will conduct a study to baseline and compare the performance of various scanners and their software for potential use in recruit clothing issue points. The proposed components of this study include product identification, hardware comparison, measurement extraction software comparison, size prediction software comparison, and hardware/software end-to-end complete solution comparison.

Status: This was the lowest priority task for Year 6 and CAR discovered that NC State University was doing a similar research project. Thus CAR only conducted evaluations of three leading 3D scanning systems and determined the Tecmath system would be ideal for a production environment. Discussions continued with the Program Manager concerning a comprehensive project at Parris Island.

At the end of Year 6 CAR, Tecmath, and Cornell University developed a detailed Year 7 proposal for a comprehensive 3-D scanning project of female Marine recruits at Parris Island. This proposal was presented to the PM and DSCP, but placed on hold for consideration under ARN II as a stand-alone project.

3.13 Task 13 – Reduce ARN Funding Needs for Manufacturing

Purpose: Minimize CAR's dependency on ARN funding for operation of the manufacturing demonstration.

***Original Task*:** CAR has been very successful in expanding production of commercial items in order to lessen the overhead funding requirements from DLA. The 60 percent contribution goal was exceeded in Year 4 and CAR will continue to reduce these requirements as seen in the following Year 6 and Year 7 budgets. As CAR increases the amount of production charged to commercial shirts and to separately contracted military items, the number of man-months of overhead charged to the Demo will continue to decrease.

Status: CAR completed Year 6 with a further reduction in manufacturing overhead funding requirements that exceeded the goal of 8 months. The recommendation was made and approved to continue the Year 7 Manufacturing Demonstration by doing the Paired Production project jointly funded by the ARN and DSCP.

4. Year 7 Technical Tasks in Detail

4.1 Task 1 – Quick Response Paired Production

Purpose: Develop and demonstrate VIM-based automated procedures to determine needs, generate delivery orders, manufacture and ship all styles of a family of items to minimize large variations in replenishment lead times.

Original Tasks: CAR will demonstrate the value of minimizing the RLT variations for a family of items by manufacturing the most urgent needs of the complete family of all 24-dress shirts in a quick response (QR) mode while the large contractors continue with their low-cost production. Production will be at the 300-shirt level per week and will continue at or above that level as directed by DSCP until 15,000 shirts are produced in Year 7. CAR will develop automated procedures to determine QR requirements by 1 April.

CAR will identify and PDIT will provide weekly the data required to prioritize DSCP's backorders for the 24 dress shirts. PDIT will automate the generation of the delivery orders once production decisions are made.

4.1.1 Paired Production Background

Paired Production refers to the same item being made on drastically different production lines. One line is designed to minimize manufacturing costs through large batch manufacturing and thus requires long lead times. The other line, a quick response line, is designed to minimize manufacturing lead times and thus costs are higher per item. Paired together, they result in lower stock outs, lower total manufacturing costs, lower inventory requirements, increased customer service, and increased customer trust. ***Most importantly, the QR line can be used to eliminate those last few long lead-time items and complete the severance of the co-variance cycles.***

Paired Production recently began to appear in commercial manufacturing in two basic models. In the first model the versatile small production line makes samples and emergency orders in a QR mode while removing the disruptions from the main lines. In the second model the large lines are moved off shore for lowest labor costs and the QR lines are retained on-shore close (in time) to retail customers. The costs per item are higher on the QR lines, but the savings from disruptions on the large lines are significantly greater. In addition, there is the additional revenue from the higher service level at retail.

Clearly, the paired lines do not have to be at the same location. The large line should be located for the lowest combination of manufacturing and shipping costs. The small line should be as close to the customer base as possible and it <u>must be tied directly into retail needs</u>. For commercial items this is becoming to mean domestic lines make the quick response needs to replenish multiple times during a season while low-cost foreign production lines make to forecasts prior to the season. Both lines have to have raw materials and operators who are skilled on the common products.

Normally for commercial items, the low-cost line makes 80 to 90 percent of the total requirements while the quick response line makes the remainder. However, in DSCP's case the contractors should make about 99 percent of all requirements at as low cost as possible as is being done today. The smallest lines need to make only about 1 percent of all requirements as quickly as possible to fill the few long RLT items before they become retail stockouts. The small lines are also ideal for making samples, "expedites," and special measurement orders.

4.1.2 Paired Production QR Military Shirt Manufacturing

CAR easily established QR dress shirt manufacturing for all 24 dress shirts because we had made them all previously as SM or standard, emergency orders. Standard production lead-time was 3 workdays and all up functions were very automated. Throughout the year this fast response capability proved extremely valuable to DSCP's dress shirt managers. They had ample high priority backorders to draw from and we were able to fill them in minimum time. The manufacturing part of this Task was mostly routine. As usual, the administrative and decision making functions proved to be the challenge.

In addition, the ARN desired that all applicable ARN solutions be fully tested by the ARN's manufacturing demonstration facility at CAR. Since CAR's ARN research contract was administered by ONR, this did not permit CAR to participate in a number of normal DSCP contracting procedures such as quality inspections and invoicing for payment. In addition, since

the manufacturing of this quantity of shirts contributed substantially to DSCP's requirements, DSCP agreed to contribute standard commercial prices for all shirts produced and the ARN agreed to fund the difference. DSCP awarded a separate contract modification for the 15,000 shirts. This permitted the appropriate use of both research and procurement funding in support of this Year 7 task.

The sub tasks were established as follows through the DSCP-funded contract modification:

CAR and DSCP will jointly determine the optimum methodology for identifying the specific NSNs and quantities to manufacture each week. This methodology will be designed for any family of items and will be refined during the demonstration and submitted to PDIT as a VIM screen candidate should DSCP determine to continue with Paired Production beyond this demonstration.

CAR will invoice DSCP the Acquisition Cut, Make, and Trim unit prices as established by DSCP. Costs incurred applicable to ongoing ARN research through this demonstration which may exceed these prices will be invoiced separately against the Demonstration contract.

There are 24 shirts and about 750 NSNs in the complete family of potential production items. The following table is a list of the 24 shirts selected for this Task:

Clemson Special Measurement Shirts						
					Shirt Specifications	
SM Item #	Name	SM ART #	PGC	DSCP Item Manager	Number	Date
0001	AF & CG, Mns, L/S 1550	397	1906	Ann Marie Mooney	MIL-S-87214B	20-Nov-92
0002	AF & CG, Mns, S/S 1550	894	2016	Ann Marie Mooney	MIL-S-87214B	20-Nov-92
0003	AF, Wms, L/S 1550	325	2240	Ann Marie Mooney	A-A-55263	4-Nov-94
0004	AF, Wms, S/S 1550	618	2241	Ann Marie Mooney	A-A-55263	4-Nov-94
0005	Army, Mns, L/S AG415	694	2120	Al Carter	A-A-52112B	16-Jun-93
0006	Army, Mns, S/S AG415	725	1672	Al Carter	A-A-52112B	16-Jun-93
0007	Army, Wms, L/S AG415	503	2282	Al Carter	A-A-55283	31-Aug-95
0008	Army, Wms, S/S AG415	290	2281	Mamie Brown	A-A-55283	31-Aug-95
0009	MC, Mns, L/S 2122	742	1876	Al Carter	MIL-S-3649G	27-Mar-90
0010	MC, Mns, S/S 2122	712	1887	Al Carter	MIL-S-19984E	20-Sep-89
0011	MC, Wms L/S 2122	669	1875	Diane Camodeca	MIL-S-29368D	6-Jun-94
0012	MC, Wms S/S 2122	614	1864	Diane Camodeca	MIL-S-29368D	6-Jun-94
0013	MC, Wms, Wh S/S 3013	793	2278	Al Carter	MIL-S-29368D	6-Jun-94
0014	Navy, Mns, pw, L/S 3346	766	186	Lynn DiVincenzo	A-A-55091	25-Feb-93
0015	Navy, Mns, pc, Wh 3013, S/S	643	184	Carol Calabrese	MIL-S-17618H	30-Sep-88
0016	Navy, Wms, pw, L/S 3346	693	1980	Lynn DiVincenzo	MIL-S-87056A	27-Nov-85
0017	Navy, Wms, pc Wh 3013, S/S	234	1629	Adele Gasparro	FNS/PD 98-03	16-Jun-98
0018	Navy, Wms, py Wh 3006, S/S	909	1829	Adele Gasparro	MIL-S-87091C	14-Sep-88
0019	CG, Mns, Util, L/S, pc 3362	301	1758	Ann Marie Mooney	MIL-S-87046A	12-Nov-86
0020	CG, Mns, Util, S/S, pc 3362	297	282	Ann Marie Mooney	MIL-S-87046A	12-Nov-86
0021	CG, Wms, Dr, L/S, pc 1550	611	2434	Ann Marie Mooney	CG-CDTO-U-008	24-Aug-98
0022	CG, Wms, Dr, S/S, pc 1550	553	2433	Ann Marie Mooney	CG-CDTO-U-008	24-Aug-98
0023	CG, Wms, Util, L/S, pc 3362	TBA	1757	Ann Marie Mooney	MIL-S-24923	29-Jul-85
0024	CG, Wms, Util, S/S, pc 3362	906	1779	Ann Marie Mooney	MIL-S-24923	29-Jul-85

DSCP had no problem identifying high priority requirements for CAR's QR production line. The following figure is the first page of a spreadsheet created from the NIR records of all 750 NSNs for these 24 dress shirts. The spreadsheet is sorted in descending order of days-of-supply of on-hand inventory to show the NSNs in shortest supply as of 1 December 2001 at the top of the list. DSCP was short almost 100,000 shirts based on its wholesale stockage policies at the beginning of this project and PGC 01876 was selected as the first shirt for production.

CAR QR Shirt Task			NIR Data Dump 3 Dec 01						[illegible]						
Sort Order	PGC	NSN	STD_UP	ORC	OH	MRQ	AMD	Size	135	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
261	2434	8405010239808	13.9	BG	0	308	142.00	SMALL		4.67	135	0	135	630	140
135	1758	8405011134636	16.1	BG	0	354	100.00	SMALL B		3.29	135	0	135	444	99
67	1980	8410012299450	25.8	DG	0	11	20.00	34X13X32 B		0.66	135	0	135	89	20
635	1875	8410014117209	19.1	BD	0	8	9.00	4S B		0.30	135	0	135	40	9
295	2433	8410014539927	21.7	BG	0	7	8.00	15 1/2X42		0.26	135	0	135	36	8
286	2433	8410014538189	21.7	BG	0	0	6.00	16 1/2X46		0.20	135	0	135	27	6
53	184	8405006298368	9.5	DK	6	113	129.00	X-SMALL B		4.24	135	1	134	567	127
576	1876	8405011734491	7.3	BC	11	109	124.00	17 1/2X36 B		4.08	135	3	132	539	122
89	1980	8410012299479	25.8	DG	4	24	40.00	38X14X34 B		1.32	135	3	132	174	39
587	1876	8405012458624	7.3	BC	24	91	115.00	17 X 37 B		3.78	135	6	129	486	113
579	1876	8405011734494	7.3	BC	6	40	28.00	18 X 35 B		0.92	135	7	128	118	28
109	1980	8410012299503	25.8	DG	31	86	122.00	42X16X34 B		4.01	135	8	127	510	120
584	1876	8405012458621	7.3	BC	28	83	109.00	15 1/2X37 B		3.58	135	8	127	456	108
563	1876	8405011734478	7.3	BC	64	195	211.00	16 1/2X33 B		6.94	135	9	126	872	208
571	1876	8405011734486	7.3	BC	116	132	177.00	17 X 36 B		5.82	135	20	115	670	175
265	282	8405014762227	13.9	BG	76	115	95.00	XX-LARGE		3.12	135	24	111	346	94
569	1876	8405011734484	7.3	BC	66	61	78.00	17 X 34 B		2.56	135	26	109	280	77
548	1876	8405011734463	7.3	BC	433	446	491.00	15 X 34 B		16.14	135	27	108	1746	484
588	1876	8405012458625	7.3	BC	41	50	44.00	17 1/2X37 B		1.45	135	28	107	154	43
66	1980	8410012299449	25.8	DG	29	22	29.00	34X13X30 B		0.95	135	30	105	100	29
68	1980	8410012299452	25.8	DG	55	24	53.00	34X14X29 B		1.74	135	32	103	180	52
549	1876	8405011734464	7.3	BC	362	307	338.00	15 X 35 B		11.11	135	33	102	1138	333
593	1876	8405012458630	7.3	BC	90	70	82.00	16 X 38 B		2.70	135	33	102	274	81
57	1980	8410012299437	25.8	DG	16	11	14.00	32X12X30 B		0.46	135	35	100	46	14
62	1980	8410012299444	25.8	DG	16	11	14.00	34X12X29 B		0.46	135	35	100	46	14
64	1980	8410012299446	25.8	DG	16	15	14.00	34X12X32 B		0.46	135	35	100	46	14
561	1876	8405011734476	7.3	BC	490	403	424.00	16 X 36 B		13.94	135	35	100	1392	418
58	1980	8410012299438	25.8	DG	16	12	13.00	32X12X32 B		0.43	135	37	98	42	13
570	1876	8405011734485	7.3	BC	245	168	197.00	17 X 35 B		6.48	135	38	97	629	194
585	1876	8405012458622	7.3	BC	201	109	155.00	16 X 37 B		5.10	135	39	96	487	153
61	1980	8410012299442	25.8	DG	21	13	16.00	32X13X32 B		0.53	135	40	95	50	16
279	2433	8410014536538	21.7	BG	24	18	18.00	15 X 40		0.59	135	41	94	56	18
80	1980	8410012299468	25.8	DG	36	16	26.00	36X15X29 B		0.85	135	42	93	79	26
83	1980	8410012299472	25.8	DG	18	12	13.00	38X13X29 B		0.43	135	42	93	40	13
69	1980	8410012299453	25.8	DG	79	54	52.00	34X14X30 B		1.71	135	46	89	152	51
74	1980	8410012299461	25.8	DG	94	45	60.00	36X13X30 B		1.97	135	48	87	172	59
564	1876	8405011734479	7.3	BC	550	240	348.00	16 1/2X34 B		11.44	135	48	87	995	343
347	1906	8405012127462	13.65	BG	426	159	269.00	16X32		8.84	135	48	87	768	265
63	1980	8410012299445	25.8	DG	26	13	16.00	34X12X30 B		0.53	135	49	86	45	16
540	1876	8405011734455	7.3	BC	286	149	165.00	14 1/2X32 B		5.42	135	53	82	446	163
49	186	8405001848698	9.5	DK	811	408	465.00	SMALL B		15.29	135	53	82	1253	459
546	1876	8405011734461	7.3	BC	468	251	262.00	15 X 32 B		8.61	135	54	81	695	258
388	2240	8410013780270	12.55	BG	316	159	168.00	10L B		5.52	135	57	78	430	166
465	1672	8405013970995	11.15	BC	646	317	339.00	18 1/2 B		11.15	135	58	77	859	334
70	1980	8410012299454	25.8	DG	113	62	59.00	34X14X32 B		1.94	135	58	77	149	58
105	1980	8410012299497	25.8	DG	58	32	30.00	40X16X30 B		0.99	135	59	76	75	30
464	1672	8405013970991	11.15	BC	494	304	251.00	19 B		8.25	135	60	75	620	248
357	1906	8405012127472	13.65	BG	909	239	425.00	16 1/2X36		13.97	135	65	70	977	419
78	1980	8410012299466	25.8	DG	484	227	226.00	36X14X32 B		7.43	135	65	70	519	223
51	184	8405001848700	9.5	DK	17889	2930	8274.00	LARGE B		272.02	135	66	69	18834	8161
54	184	8405014438957	9.5	DK	1269	271	559.00	XXL B		18.38	135	69	66	1212	551
553	1876	8405011734468	7.3	BC	1439	578	624.00	15 1/2X33 B		20.52	135	70	65	1331	615
559	1876	8405011734474	7.3	BC	1578	477	665.00	16 X 34 B		21.86	135	72	63	1374	656
594	1876	8405012458631	7.3	BC	316	102	133.00	16 1/2X38 B		4.37	135	72	63	274	131
557	1876	8405011734472	7.3	BC	320	105	133.00	16 X 32 B		4.37	135	73	62	270	131
56	184	8410012299436	25.8	DG	46	13	19.00	32X12X29 B		0.62	135	74	61	38	19
329	1906	8405012127444	13.65	BG	199	49	81.00	14 1/2X33		2.66	135	75	60	161	80
44	186	8405014433793	25.9	DG	89	35	36.00	1812 X 38 B		1.18	135	75	60	71	36

CAR immediately ordered GFM and began producing PGC 01876, Marine Corps Men's Long Sleeve shirts upon verbal approval by DSCP pending award of DSCP's contract modification. CAR quickly consumed all available SM fabric and sent operators home pending receipt of GFM. GFM was received in January and CAR produced about 600 total QR shirts before DSCP directed CAR to cease production until their portion of he contract was in place. DSCP funded their portion of this Task as a contract modification in March and production began at the 300 shirt per week level. CAR was not able to make up the shortfall that occurred at the beginning of Year 7 so the Task was extended for 4 months to provide for a full year of production. Near the end of the extension DSCP's high priority backorder status was significantly improved and insufficient orders were generated to get to the complete 15,000 shirts originally targeted.

CAR identified all the data fields required for this Task and determined the automation sub-task was actually a special version of VIM-BIFRS. Detailed computations were developed and passed to PDIT for use in VIM-BIFRS. CAR completed the set-up of a Web site for DSCP Item Managers to use in making final selections of shirts to place on CAR's weekly delivery orders.

Accurate intransit inventories and expected near-term contractor shipments are problematic. By May CAR had made 11 of the 24 different styles of these dress shirts and learned that access to accurate intransit inventories and near-term shipments from other contractors were critical for the success of this Task. Limited fast-turn production capacity must only be used for the most critical backorders. We developed the automated capability to display all current backorders by a priority based on days-of-supply on-hand in the wholesale system. This was a solid starting point, but only the Item Managers could provide the last two pieces of information required to make the final selection of the most urgently needed shirts.

First, we had to capture all intransit inventories because they were not included in the wholesale inventories and initial priorities. If we ignored intransits, we would frequently use our limited fast-turn capacity to make the intransits again. Based on our request, PDIT did extensive investigations into the sources and accuracy of intransit data and developed reasonably accurate extractions.

Second, we had to know with a great deal of accuracy the expected shipping dates and quantities of the backorder items from all the active contractors so we could avoid duplicating these items on the QR production line. We learned that only the Item Managers had this information and they maintained it in their individual "shadow" logs or spreadsheet systems especially for PGCs that were in trouble.

Thus, our extraction of all backorders and prioritization by days-of-supply oh-hand was as far as we could go with the automated down-select process. Item Managers could easily complete the down-selections from this listing based on their current knowledge of intransits and expected near-term shipments from other contractors.

In August PDIT provided all of the data we needed to build the automated priority listing of backordered items for DSCP's Item Managers, but DSCP decided this work should be terminated because they had no interest in making expedite ordering decisions in this manner. DSCP encountered the normal year-end funding shortage at the end of August and placed

delivery orders on hold. By the time orders commenced again in September, the number of backorders had increased greatly. The emergency needs were so abundant that Item Managers had no problems in identifying candidate fast-turn shirts for CAR.

This Task was originally scheduled to terminate in November, but at that time DSCP still needed help with backorders and sufficient ARN and DSCP funding was available to continue fast-turn manufacturing for a full year as originally planned. An extension was granted through March.

Validating technical changes with the fast-turn manufacturer. In December CAR received its first orders for Coast Guard Shirts and cut 300 shirts. There was a problem in sewing the cut parts together correctly and, in exploring the reasons for the problem, we discovered new specifications and patterns had been issued since our contract was awarded. We were not aware of this and had to dispose of the cut fabric because there had been a significant style change. The Coast Guard would not accept the old style. It is understandable how CAR slipped through the crack when the new specifications and patterns were distributed because we were not a primary contractor. However, the lesson learned here is that full-scale validation of technical changes could be accomplished very quickly and easily if a fast-turn line existed.

4.1.3 Impact of Paired Production on DSCP Contractors.

At the completion of QR manufacturing, CAR developed and distributed the questionnaire at Appendix 1 to the major dress shirt manufacturers to evaluate the impact of Paired Production on the low-cost contactors. All contractors but one responded.

Impact of making SM Shirts. The respondents strongly prefer not to make SM shirts primarily because of the disruptions they cause, but also because of the added costs. Only one company that has not made SM shirts indicated they would be interested in making them. If the contractors are required to make SM shirts, their estimates of increased costs range from 30 percent more per shirt to 300 percent more than for making standard sizes. Follow-up discussions determined none really know what their actual costs would be – especially the cost of disruptions throughout their processes. (Our original engineering study in 1995 and 1996 of SM dress shirt manufacturing costs was that a SM shirt cost DSCP's manufacturers at least $125 per SM CLIN and 80 percent of all SM CLINS are for one shirt. A separate study by KSA of about the same time period found that SM trousers cost approximately $80 to make.)

The respondents felt that they could produce SM shirts by expediting production on their low-cost lines in a range of 2 to 4 weeks from order receipt. This is not adequate for high priority recruit needs.

Impact of making QR Shirts. The majority of the respondents prefer to make all standard sized shirts including emergency orders. One manufacturer would be willing to give up 5 percent of total manufacturing requirements to avoid the emergency orders. They estimate their costs of making small, emergency orders ranges from no additional cost to 75 percent additional cost. As emergency orders approach sufficient size to permit full cuts in conjunction with normal orders, their additional costs approach zero. The expected lead-time for emergency orders is 3 to 4

weeks, which is slightly less than their standard lead-times. The key here is that emergency orders should be large enough to eliminate most of the manufacturers' additional costs.

Conversion to QR manufacturing. Responses varied greatly concerning abilities and desires to establish a small QR line in addition to standard low-cost lines. The majority of respondents would not consider establishing a QR line because different processes would have to be done at different locations, they would not have the skills to handle garments other than the ones they make on standard contracts, and there would be a loss of focus on their low cost manufacturing strategy. Another respondent supports establishing a QR line, but estimates they would need about 1200 shirts per week at 3 times normal prices, 20 to 26 weeks to get up the learning curve to full productivity, and at least 9 months of work to recover all investment costs for starting the QR line.

Contractors' willingness and capabilities to establish QR lines also varied widely by manufacturing function. Most have flexible order planning and marker making from internal or external sources. Generally they can handle some QR cutting by adding labor, but a large quantity of QR cutting would seriously degrade their cutting operations. As expected, sewing is the primary function that the majority of respondents are not willing to convert to QR.

Contractors feel that they do not lose a lot of money on QR orders because most are large enough and can be integrated in with normal manufacturing. Premium prices also assist greatly in off setting their additional costs. They are willing to expedite the front-end and shipping functions, but they avoid expediting on the production floor if the nature of the expedited orders would disrupt production on the sewing floor. In addition, they feel that by going out of their way to meet DSCP's emergency needs, their past performance will be rated higher during best value bid evaluations.

Paired Production survey summary. Experienced contractors do not want to return to making SM shirts because of the disruptions and financial losses they cause. These disruptions are very costly in every business function, but they do not know how costly they are.

The majority of contractors will not consider establishing QR lines because of disruptions to their low-cost manufacturing strategies on the sewing floor. They prefer to make all emergency needs within slightly shorter than standard lead-times provided their extra costs are covered by increased prices. If the emergency orders are large enough they are combined with normal orders on an expedited basis, moved to the head of the cutting queue, and do not cause disruptions on the manufacturing floor. This actually cuts weeks off the normal process because delivery orders are issued so far in advance of required shipping dates.

4.1.4 Paired Production Summary

DSCP must create redundant supply chains for all items that are viewed as critical by the Services. Some items already have redundant lines because multiple contractors are required to meet total requirements. The implementation of BIFRS will further reduce the need for redundant lines, but QR Paired Production Lines will be required to completely eliminate the

final few retail stockouts. DSCP simply cannot achieve this within current systems and with single supply sources. Paired Production will complete the elimination of the co-variance cycles and enable the ARN to achieve completely its goals of no retail stockouts with minimum inventories, item costs, and operational expenses.

4.2 Task 2 - VIM-BIFRS Roll Out of Additional Recruit Items.

Purpose: Roll out BIFRS-W to reduce retail stockouts, supply chain inventories, and expediting at DSCP and at contractors.

Original Tasks:

The goal for this task consists of 3 objectives:

1. Use VIM screens to manage the entire process so Item Managers can efficiently and accurately determine requirements and generate delivery orders.

2. Generate new DOs that re-balance NSNs (and PGCs within the same production plants) in days-of-supply at or near the policy targets for the wholesale and manufacturing portions of the supply chains.

3. Generate DOs that maintain level manufacturing requirements in optimum production quantities.

CAR will function as wholesale item managers and, with support of DSCP Item Managers, will extend VIM-BIFRS to selected manufacturers beginning with all RutterRex contracts. CAR will continue with the target of generating a new DO about every 90 days for each contract and will use VIM-BIFRS to monitor the status of each supply chain once a week.

Outside Support Requirements:

DSCP must select contractors and Item Managers must work closely with CAR in each roll out. DSCP must direct selected contractors to participate in VIM-ASAP and the VIM-BIFRS roll out. DSCP Item Managers must take over responsibility for running VIM-BIFRS once CAR reaches a full workload level that is expected to be about 60 items. CAR plans to generate two successful delivery orders before turning each item over to DSCP.

PDIT and CAR must set up each contractor and contract on VIM-ASAP so CAR can activate them on VIM-BIFRS. PDIT must implement the changes currently identified to make the VIM-BIFRS Table fully functional. CAR will provide final versions of the additional worksheets by the end of March and PDIT must add these to VIM-BIFRS by the end of April so CAR can begin to pass responsibility to DSCP Item Managers in May.

Milestones:

CAR will activate RutterRex contracts by 1 March on VIM-ASAP and BIFRS. Thereafter, CAR will activate new contractors at the rate of one per week and add one contract per workday until approximately 60 contracts are on VIM-BIFRS. This rate will continue for the year provided routine applications are transitioned to DSCP Item Managers.

Status: The AG 415 Shirt RutterRex was manufacturing and was used as the VIM-BIFRS test in Year 6 remained the primary test shirt at the beginning of Year 7. In January DSCP cut the first DO using output from manual BIFRS and CAR began contacting one new contractor per week to assist them in the use of VIM-ASAP. With CAR's assistance RutterRex began to use VIM-ASAP in December. CAR contacted the DSCP Item Managers and determined approximately when the next DO was due for each contractor scheduled for VIM-ASAP activation. Since new DOs are generated for each item about every 12 weeks, we needed approximately 12 items on VIM-ASAP and VIM-BIFRS so we could do one DO per week. We had to skip all items that were in short supply because VIM-BIFRS could not be used to modify existing DOs.

By March CAR was having great difficulty getting contractors to participate in VIM-BIFRS. Most of the first contractors selected had developed internal software that they considered adequate for doing the new functions VIM-ASAP was designed to do. Since this was not a contractual requirement, they declined to participate. Some refused to participate because they were not willing to share the information requested. Others promised to participate, but never had the time to spend learning how to use VIM-ASAP. CAR suggested and DSCP agreed to send a letter to selected contractors urging or requiring them to participate.

CAR originally designed BIFRS to generate new delivery order recommendations with optimum cut quantities to reduce production lead-times and manufacturing costs in accordance with the objectives for this Task. However, DSCP decided this was inappropriate action for DSCP to be involved in and item managers were not capable of handling it properly. The decision was made to eliminate this feature from the BIFRS computations.

In April CAR was still running local BIFRS using data from the SAMMS Data Warehouse because VIM-BIFRS was not fully operational. CAR encountered two problems in using the SAMMS Data. Average Monthly Demand (AMD) fractions were correct in the Data Warehouse, but were rounded up to the next whole numbers for HTML displays. These differences only applied to AMDs of less than one item, but resulted in large differences in months and days of supply on hand. Upon investigation it was determined that PDIT was acquiring the correct data for posting to the ARN database.

The second problem was that CAR's new DO recommendations did not match some IM's DO decisions because CAR was not using the proper Due-In and intransit information. The item managers did not trust the accuracy of the SAMMS intransit data so they all tracked their own using "shadow" spreadsheets driven by copies of DD250s and warehouse receiving reports. They used this information to adjust the SAMMS-generated new DO requirements. CAR did not use these adjustments in BIFRS calculations.

Since the plan was to eventually use data from the ARN database to drive VIM-BIFRS, we made the decision to place VIM-BIFRS on hold until this data could be provided by PDIT through the ARN database. The milestone for VIM-BIFRS was established for June.

In June the decision was made to assign the Task of completing VIM-BIFRS to CAR because of higher ARN priorities for PDIT. PDIT continued to work on extracting acceptable intransit data from the SAMMS system.

CAR decided to use its commercial BalancedFlow software as the basis for VIM-BIFRS. This eliminated the programming problems PDIT had encountered and provided vastly more capabilities than just generating new DOs. In addition, this version of BIFRS it would be in place and available to scale up to generate order, ship, or make quantities for upstream SC sections at any time.

In August PDIT provided the first complete set of input data for VIM-BIFRS, but we discovered the inventory data was missing for Parris Island. PDIT identified the problem and had the fix in place by September.

Item Managers have to determine for each new DO not only the total quantity and the quantity by size, but also the quantity by size by ship-to location. BalancedFlow was fully capable of providing this level of detailed output, but to do this a demand forecast and on-hand inventory must be input for each storage site. A demand forecast was not readily available by storage site from SAMMS. In addition, the decision was made that BSM determines how much to stock by specific location for new delivery orders so VIM-BIFRS was only required to generate total recommended DO quantities by item size. Item Managers would be responsible for deciding the distribution of the totals for each size until BSM became operational and did this function.

Just computing total requirements by size to re-balance the SC in DOS still had one unique challenge. Items in long supply at one or more locations should not be used to off set needs at other locations. This feature was programmed in the new BIFRS.

A new program was required to extract the data from the PDIT data files, combine it, and post it to the forecast and inventor input files required by for BalancedFlow. Extensive data extraction logic was developed and the program was written and tested in approximately one month. The logic for this program is at Appendix 2 and an electronic copy of the program is available upon request.

In November the first fully operational version of BIFRS was provided to DSCP for evaluation. The evaluation resulted in the need for many cosmetic modifications that were made and tested in December. In addition, the data for all 24 dress shirts was loaded into BIFRS and tested successfully in December. After the first shirts were loaded and tested, we found additional items with many NSNs could be completely loaded in less than 30 minutes and new delivery orders could be generated in less than 5 minutes. It is clear that BIFRS offers many operational advantages to Item Managers over the current SAMMS system. The two key advantages are graphical total asset visibility with supporting data tables and efficient generation of new DO requirements.

The final draft of the detailed BIFRS Operational Manual was completed for Item Managers in January and a review of BIFRS was scheduled for February. Funds for the Year 7 extension were exhausted in January.

CAR met with the dress shirt team in February at DSCP to provide an overview of BIFRS. It became clear in the demonstration that the shirt managers do not trust SAMMS data for intransit inventory status because they all maintain their own spreadsheets to keep up with DD250 transactions and shipments. However, they were very positive about BIFRS' ability to easily display total asset visibility through the RTC level and efficiently generate recommended delivery order quantities. In addition, they were very pleased that they could have direct access to the BIFRS' input data so they could correct intransit information based on their spreadsheets prior to generating recommended orders. Originally we had not planned to make this input accessible in the final version so we must accommodate this requirement in the next version of BIFRS.

The decision was made that the next step would be to provide DSCP a copy of the software and documentation on a CD so they can work with it. This has not been done because funding was not available to complete some minor programming, integrate the PDIT download and extraction software, and build the CD. Plans are to have a graduate student complete this during summer employment.

4.3 Task 3 - Upgrade EOF

Purpose: Maximize the use of the EOF by extending it to all special measurement clothing, by making it more user friendly, and by upgrading its programming to current Web-based standards.

This task originally consisted of two phases:

<u>Phase I - Expand EOF to include all special measurement clothing and make it more accessible and user friendly</u>.

CAR will add non-bag items to EOF. This consists of adding garments for which sufficient measurements are available and garments for which sufficient measurements are not available. The total number of garments and priorities has been determined by DSCP. Garments for which all measurements are already included in EOF will be added individually. All new garments have been identified so new measurements can be determined. Models and other sub-contractors can then be brought in to create all the new measurements and videos at one time.

CAR will make EOF even more user friendly. Because of the numerous ordering sites and ordering officers as well as the infrequent need for EOF, it is clear that we cannot expect to train the EOF users before they need to order SM garments. Therefore, the on-line EOF must consist of all the necessary "just-in-time" training and be compartmentalized so each user can go directly to just what they need for each ordering session. In addition, the capability to print out ordering

forms will be modified so users can obtain just the EOF forms required for the specific item and measurements they need. This will help replace the old, incomplete manual forms that are causing all the problems today.

Phase II – Rewrite EOF Programming.

The EOF software was groundbreaking in both concept and software when it was written over 5 years ago. The concept and strategy remain absolutely solid. However, robust Internet development software has become available that will make it much more user-friendly, reliable, and secure. The EOF has no significant protection from hackers as this threat was not known and today's level of security was not available when it was created. The EOF must be updated before it can be transferred to any other agency for operation, maintenance, and security.

CAR will maintain all the proven functionality, but rewrite the software and add a replacement database using Microsoft ASP.NET and SQL server. This new software and database will permit the files to be made secure, will permit on-line help, and will permit the order to be initiated on-line at one location and to be completed later on-line at a second location by the ordering officer. In addition, CAR has verified that the new software and database will be fully compatible with the other ARN efforts.

CAR will coordinate with other ARN researchers involved with 3D body scanning so electronic measurements can be fed into the EOF to drive special measurement ordering without manual data entry. This will complete the special measurement cycle for customer driven uniform manufacturing (CDUM).

Status: This Task was commenced and significant progress was made before funds were exhausted in January. CAR continued this project using its own funds and conducted major modifications to the existing EOF at DSCP's request.

This Task was revised by the addition of Phase III for the transition of EOF to PDIT. The new EOF Task was funded as a stand-alone ARN Task in April.

4.4 Task 4 - Automate DSCP's Special Measurement Marker Making

Purpose: Maximize the use of fully automated special measurement marker making to improve customer service and reduce all costs.

This is a new Task that will demonstrate the benefits of extending CAR's automatic marker making for shirts to other items and other manufacturers. The term "automatic marker making" or "marker making" or "marker" refers to plot and cut files as well as printed markers throughout this Task. This is a pilot test using the shipboard coveralls, but it will demonstrate the benefits of fully automated marker making for all SM items.

CAR Tasks:

CAR will visit DSCP to flow and document in detail the procedures and times required to generate the current SM marker files that DSCP sends to garment manufacturers. CAR will capture the objective and subjective rules DSCP uses in determining appropriate pattern dimensions based on incoming body measurements.

CAR will coordinate with the manufacturer of the coveralls so the output file is ready for production. CAR will capture the amount of time and cost saved by using the new markers.

CAR will use the same input that DSCP uses to produce markers that replicate those made by DSCP. Once CAR's markers are acceptable to DSCP, CAR will produce production markers and follow their use by the manufacturer until all problems are resolved.

CAR will provide an objective comparison of times and costs of the current and new systems so DSCP can determine if the pilot process should be expanded to other items.

Outside Support Requirements: DSCP must demonstrate their current process to CAR and share all decision-making rules used in generating markers for the SM coveralls. DSCP must direct the SM contractor to work with CAR and to provide their unique manufacturing needs for their markers.

Status: In December CAR obtained the first coverall pattern and converted it from MicroMark to AccuMark. In January CAR and DSCP determined the additional measurements that must be obtained for coveralls were torso length and knee height. CAR commenced modifying the marker making program and cleaning up the coverall pattern.

Funds were exhausted and work ceased in February. CAR then lost our only patternmaker and an agreement was made that CAR would re-submit the Task for continuation with DSCP funding when a new patternmaker was available. The new patternmaker was hired in July and met with DSCP in August to discuss restarting the Task. A comprehensive proposal covering the original Task plus the automation of the remaining special measurement processes was submitted, but DSCP eventually decided the Task would be re-opened for competition.

4.5 Task 5 - Optimize Stockage Objectives.

Purpose: Provide Wholesale Item Managers a tool to optimize stockage objectives.

DSCP has established policy levels for overall wholesale inventory stockage and the ARN has provided a number of capabilities to optimize replenishment from manufacturing forward to and including the recruit training centers. DSCP continues to create regional Vendor Parks to improve distribution reaction times, improve quality and lower distribution costs. However, there is no objective way for Item Managers to determine optimum stockage target levels for each wholesale storage site at the NSN level so they must rely only on their experience and judgment. SAMMS does not facilitate this decision-making because it only displays the on-hand and due-in quantities for each stockage location.

CAR will modify its current optimization model to recommend optimum stockage levels at the NSN level for items at RTCs and supporting wholesale locations. Input will consist of supply chain structure, annual historical demand in the form of requisitions and cost parameters such as the cost of holding inventory at each location in the supply chain. Output will be recommended stockage targets for each of the RTCs and supporting wholesale storage locations.

Status: CAR developed the initial prototype of a web application for the decision support system, but funds were exhausted while waiting for Year 7 funding. When funds were available in March, the decision was made to terminate this project.

Apparel Research Network
Clemson Apparel Research
Special Measurement and Quick Response
Shirt Manufacturing Survey

May 5, 2003

Appendix 1 – Special Measurement Shirt Questions

Special Measurement Shirt Questions

1. How much do you estimate you lose per shirt when you are required to make SM shirts at standard price? ____ Nothing ____ 2X Standard Price ____ 3X Standard Price ____ 4X Standard Price ____ More than 4X Standard Price.

2. Would you prefer to make SM shirts for DSCP as part of your contracts or have someone else make them for DSCP? ____ Make all requirements ____ Let someone else make them.

3. What would be the best lead-time you could consistently meet now to ***deliver*** high priority SM shirt orders without a significant investment in a QR production line? ____ One Week ____ Two Weeks ____ Three Weeks ____ Four Weeks.

4. At what price (as a multiple of standard commodity shirt prices) would you be willing to make SM shirts as part of your contracts on your existing production lines? ____ Standard Price ____ 2X Standard Price ____ 3X Standard Price ____ 4X Standard Price ____ Not at All.

Quick Response Shirt Questions

5. How much do you estimate you lose per shirt when you are required to make QR shirts (small emergency orders) at standard price? ____ Nothing ____ 1.25X Standard Price ____ 1.5X Standard Price ____ 1.75X Standard Price.

6. What would be the best lead-time you could consistently meet now to deliver high priority QR shirt orders without a significant investment in a QR production line? ____ One Week ____ Two Weeks ____ Three Weeks ____ Four Weeks.

7. Would you prefer to make all standard-sized shirts for DSCP including emergency expedite orders or have someone else make the expedites. ____ Make all Requirements ____ Let Someone Else make Expedites.

8. What percentage of your contract quantities would you be willing to forego for someone else to make DSCP's emergency expedite orders? ____ None ____ 1% ____ 2.5% ____ 5% ____ 7.5% ____ 10%.

Appendix 1 – ARN QR/SM Shirt Survey May 2003

Conversion to Quick Response Manufacturing

We assume that if you are required to make SM and QR shirts you would "expedite" them on your existing manufacturing lines because there would be insufficient payback to establish your own QR lines. We would like to validate this assumption and learn of your concerns in establishing a QR capability. There are several major steps and associated costs in establishing a QR manufacturing capability. Please comment on the feasibility of moving from where you are now to QR capabilities in each of the following areas:

9. Order planning and marker-making:

10. Cutting:

11. Sewing Equipment:

12. Establishing the QR line:

13. What would you estimate to be the minimum number of dress shirts per week to sustain a SM/QR line within your operations? This would be a line that makes all styles of military dress shirts and ships them in about a week.

14. What would you estimate the payback period to be in months for creating a QR production line making the quantity of shirts listed above for each of the following shirt prices: ________1X Standard Price ______ 2X Standard Price _____ 3X Standard Price ________4X Standard Price

Other Comments

15. Would you be willing to bid on a contract for making all SM and emergency dress shirt orders for delivery of high priority needs within 7 days and normal priority needs within 14 days? ____ Yes ____ No.

16. If your response to # 15 is "No," what would be required for you to change your response to a Yes?

Appendix 1 – ARN QR/SM Shirt Survey May 2003 (Page 2)

Appendix 2 – Logic for Extracting Data from AAVS Files

Logic for extracting BIM-BIFRS On-Order, Backorder, and Intransit input data from PDIT files

Row	*Bold & Italics new field names*	Bold for current fields
	ACF Input File - Computing On Order QTY still Due-in on Delivery Orders -	**(OOQTY)**
1		**Elimi**
2	Sort ACF table by **NSN** and **STG_LOC_RIC_2**	[STG_LOC_RIC_2 is the contractual ship to address]
3	Create new fields named ***OOQTY, ToSCS#, and MakeSCS#***	
4	***OOQTY*** = **QTY** minus **RECEIPT_QTY**	
6	IF ***OOQTY*** is negative, change it to 0.	
5	*Separate the* ***DODAAC*** *from the Document Number in the* ***DOC_NR*** *Field of the* ***ACF File***	
7	IF **STG_LOC_RIC_2** is a RIC found in the RIC field on the X-Ref Table	
8	***ToSCS# = SCS#*** *from* ***SCS Address X-Ref File*** *based on* ***RIC*** *Code*	
9	Otherwise	[STG_LOC_RIC_2 is not a RIC found on the RIC field on the X-Ref File]
	If the ***DODAAC*** *equals a* ***DODAAC*** *in the* ***TIER Field*** *of the* ***X-Ref File***	
	ToSCS# = SCS# from ***SCS X-Ref File*** *base*d on the **TIER** field of the ***X-Ref File***	
	Otherwise set the **ToSCS#** to "1~RET"	[Because it is a DVD to a RETAIL customer.]
11	In Software that creates Inventory.csv	**[Must wait until after BB records are added below to sum]**
12	IF ***OOQTY*** is greater than 0	
13	Extract ***OOQTY*** and sum by NSN and ***SCS#*** as it is posted into Inventory.csv as PO.	
14		
	NIR2 Input File - Extracting and Summing On Hand QTY at RICs -	**(OHQTY)**
20		
21	Sort NIR2 table by **NSN** and **LOC_RIC**	[LOC_RIC is the storage site that has the inventory.]
22	Create new fields named ***OHQTY, RIC***, and ***OHSCS#***	
23	IF OP_CD and COND_CD both equal "A"	
24	***RIC*** = **LOC_RIC**	
25	***OHQTY*** = **OH_BAL_QTY**	
26	If ***RIC*** is not blank and ***OHQTY*** > 0	
27	***OHSCS# = SCS#*** from ***SCS Address X-Ref Table***	
28		
29	In Software that creates Inventory.csv	
30	IF ***OHQTY*** is greater than 0	
31	Extract ***OHQTY*** and sum by NSN and SCS# as it is posted into Inventory.csv as TBOH.	
32		

Appendix 2 – Logic for extracting data from PDIT files

No.	Logic	Comment
	ARCS2 Input File - Extracting Intransits to RICs not Yet Shipped -	**(ITQTY)**
40	Sort **ARCS2** table by **NSN and SHIPTODODAAC**	[SHIPTODOAAC is the only valid ship-to field]
41	Create new fields named ***RIC, ITQTY, BOQTY, OOQTY, and ToSCS#***	
42	If **SHIPTODODAAC** is for a RIC (on the RIC X-ref file), add the RIC to the new field named ***RIC***	
43	IF **STATUS_CD** = "BA" and ***RIC*** is a **RIC**	[Captures MROs not yet on SS status only to RICs.]
44	***ITQTY*** = **QTY**	[ITQTY is established only for RICs]
45		
	ARCS2 Input File - Extracting and Summing Intransits Shipped to RICs -	**(ITQTY)**
50	Sort **ARCS2** by **NSN** and **DOC_NR**	
51	IF **STATUS_CD** = "SS" and **RIC** is not blank and	[Eliminates BA and BB and SS to non-RICs.]
52	IF **ConUS** = "ConUS" and **STATUS_DT** is less than 30 days old or	[Eliminates overdue intransits.]
53	IF **ConUS** = "OConUS" and **STATUS_DT** is less than 60 days old	
54	***ITQTY*** = **QTY**	
55	IF ***ITQTY*** > 0	
56	Sum ***ITQTY*** by **NSN** and **RIC** and **DOC_NR**	[Combines so can reduce receipts in DUE File below]
57	Extract one record with QTY summed by **NSN, RIC,** and **DOC_NR** into new ***SS Intransit Table***	
	ARCS2 File - Assigning BB Backorders to RICs and Non-RICs -	**(BOQTY)**
60	Sort **ARCS2** by **STATUS_CD** and **NSN**	
61	If **STATUS_CD** = "BB"	
62	***BOQTY*** = **QTY**	[Assigns BB backorder QTY to BOQTY field for all records.]
	Append records to ACF File with **NSN** & **ToSCS#** = "2~TOTAL" & OOQTY = BB QTY from ARCS2	
	If **ShipToDODAAC** is for a DODAAC in the TIER Field of the **X-Ref File**	
	and the the TIER Field of the **X-REF File** is not "2~TOTAL"	
	Set the ***ARCS2 ToSCS#*** equal to the ***SCS#*** from *the **X-Ref File***	
	Otherwise set **ARCS2 ToSCS#** equal to "1~RET"	
	DUE Input File - Computing Intransits not received by RICs -	**(ITQTY)**
70	Sort **DUE** by **NSN** and **DOC_NR**	
71	Compare **Due DOC_NR** to ***SS Intransit Table*** **DOC_NR**	
72	*Set **ITQTY*** on **ARCS2** = ***SS Intransit Table QTY*** minus **DUE RCVD_QTY**	
73	Change ***ITQTY*** to "0" if negative	
	ARCS2 File - Setting ToSCS# Values for Intransits	**(ITQTY and BOQTY)**
	If **ARCS2 *ITQTY*** > 0 and ARCS2 Status_Code equals "SS"	
	IF **ShipToDODAAC** = DODAAC in TIER Field of **X-Ref File**	
	Set ***ARCS2 ToSCS#*** equal to X-Ref File ***SCS#*** *based on TIER Field in **X-Ref File***	
	Otherwise set ARCS2 ToSCS# equal to "1~RET"	
83		
	ARCS2 File - Extracting and summing Intransits and Backorders -	**(ITQTY and BOQTY)**
90	In Software that creates Inventory.csv	
91	If ***ITQTY*** > 0	
92	Extract ***ITQTY,*** sum it by NSN and ***ToSCS#,*** and post sum to Inventory.csv as WIPa by SCS#	
93	If ***BOQTY*** > 0	
94	Extract ***BOQTY,*** sum by NSN and ***ToSCS#,*** and post sum to Inventory.csv as PO by SCS#	
95		

Appendix 2 – Logic for extracting data from PDIT files (Continued)

Appendix 3 - Acronyms

ADOS	Average Annual Days of Supply. Number of ***days*** of expected demand a given quantity of items will last based on the AADOSr.
ADOSr	One Average Annualized calendar Day Of Supply consumer pull ***rate*** computed by dividing the forecasted annual demand quantity by 365 days.
AMD	Average Monthly Demand computed by dividing the total demand for a year by 12.
ARN	The Apparel Research Network.
ARN-AIMS	The ARN Apparel Information Management System created by Georgia Tech and modified greatly by CAR and used by CAR as its manufacturing data management system.
ASAPWeb	The original version of what has evolved into VIM-ASAP.
BF	BalancedFlow is the overall concept for advanced supply chain scheduling and execution created by CAR.
BIFRS	Balanced Inventory Flow Replenishment System is the original military concept for advanced supply chain scheduling and execution.
BIFRS-DSS	Balanced Inventory Flow Replenishment Decision Support System is the software package developed by CAR for retail military clothing issue facilities to use to determine optimum order quantities and stockage target levels.
BIFRS-R	Balanced Inventory Flow Replenishment System Retail is the military version of the BIFRS software used only to generate replenishment requisitions in MILSTRIP format.
BIFRS-W	Balanced Inventory Flow Replenishment System Wholesale is the military version of the BIFRS software used to generate shipping and delivery order requirements.
BIO	Basic Inventory Objective is the quantity of an item that should be in stock all year to meet basic demand. Does not include the stocks required to meet seasonal or surge demand.
BSM	Business System Modernization.
C&T	Clothing and Textiles.
CAL-POLY	The University of California at Pomonia.
CAR	Clemson Apparel Research.
CART	Clemson Apparel Research Translator. Software that eliminates the need for a contractor to have to use DAMES or EDI when receiving delivery orders and transmitting order status to SAMMS.
CDUM	Customer Driven Uniform Manufacturing – the original and current ARN vision.
CLIN	Contract Line Item Number.
CWT	Customer Wait Time.
DAMES	The standard military communications system that C&T contractors must use when they operate in a bill and hold mode.
DataMart	The ARN database that contains all of the data required by ARN partners.
DO	Delivery Order.
DOS	Days of supply.
EDI	Electronic data interchange.
EOF	Electronic Order Form for ordering special measurement garments.
FLW	Fort Leonard Wood.
GFM	Government Furnished Material.
JROTC	Junior Reserve Officer Training Command.
MUMMS	Marine Corps Uniform Material Management System.
NIR	National Inventory Record.
NSN	National Stock Number.
ONR	Office of Naval Research.
OST	Order Ship Time.
PDIT	ARN partner now named Modulant.
PGC	Procurement Group Code.
QLM	Quality Logistics Management.
QR	Quick Response.

RLT	Replenishment Lead-Time.
RTC	Recruit Training Center.
SAMMS	C&T's material management system.
SC	Supply Chain.
SIO	Surge Inventory Objective – the quantity of an NSN required to meet anticipated surge demand. Does not include the Basic Inventory Objective.
SM	Special Measurement.
TAV	Total Asset Visibility.
TO	Total inventory Objective is the sum of the BIO and SIO.
TOC	Theory of Constraints.
TQM	Total Quality Management.
VIM	Virtual Item Manager.
VIM-ASAP	Virtual Item Manager Web-based tool for providing delivery order status and collecting manufacturing and shipping status.
VIM-BIFRS	Virtual Item Manager tool for running BIFRS for C&T Item Managers.
VMI	Vendor Managed Inventory.
VPSE	Vendor Park, SouthEast.
VPV	Virtual Prime Vendor.
WIP	Work In Process.